FACTORS AFFECTING THE THAI NATURAL RUBBER MARKET EQUILIBRIUM: DEMAND AND SUPPLY RESPONSE ANALYSIS USING TWO-STAGE LEAST SQUARES APPROACH

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ABSTRACT

Factors Affecting the Thai Natural Rubber Market Equilibrium: Demand and Supply Response Analysis Using Two-Stage Least Squares Approach

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Natural rubber is a major export crop and the sector is an important source of employment in Thailand. Very few rubber studies in the past have examined the demand and supply equations simultaneously and the previously results are dated. The objectives of this study was to estimate the econometric model of demand and supply of natural rubber in Thailand and determine if a relationship exists between the supply of rubber and its determinants. The data contained in the study are secondary time series annual data from 1977-2012. The instrumental variables estimation by two-stage least squares was used to solve and analyze the demand and supply of rubber. Results were statistically significant at 0.01 level, which showed that the U.S. GDP per capita, the estimated price, rainfall and rice price have a significant effect on quantity of rubber production in Thailand with an estimated elasticity of 1.4, 3.3, -3.6 and -2.6, respectively. The implications of the results are assessed through the lens of rubber producers, rubber consumers and agricultural policy makers.

Keywords: natural rubber, supply response, Thailand, simultaneous equation, two-stage least squares, instrumental variable estimation

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INTRODUCTION

Natural rubber (rubber)[1] is a high-value export-oriented crop that has seen rapid emergence and expansion across Southeast Asia in the last several decades. Traditionally, the rubber trees are native to the tropical zone and have been cultivated in plantations in mainland Southeast Asia, including portions of southern Thailand, south-eastern Vietnam, southern Myanmar and the Malaysian Peninsula. More recently, rubber can be grown in the upland areas of China, Laos, Thailand, Vietnam, Cambodia, and Myanmar, where rubber trees were not traditionally planted (Fox and Castella, 2013; Barlow, 1997; Manivong and Cramb, 2008; Li and Fox, 2011; Ziegler, Fox and Xu, 2009).

Natural rubber is an economic crop and a substantial product of Thailand. It has been developed and expanded to being planted in every part of the country. After over 40 years of improvement Thai natural rubber production has become very efficient. The government has launched various policies and measures such as research in high-yielding varieties, good-practice reaping systems and tree maintenance, and teaching new technology to farmers. To improve rubber production, the government helps farmers replant old rubber holdings with high output varieties, and introduced modern process of cultivation with the replanting project (Soontaranurak, 2011).

[1] Appendix 5

In 2004-2006, the government launched the One Million Rais[2] Project, which aimed to establish 160,000 hectares of new rubber acreage in Thailand (Department of Internal Trade, 2003). This was a goodwill gesture by the government to increase income to farmers, with the ultimate objective of mitigating poverty. The Thai Department of Agriculture reported that the natural rubber area of planting is more than 3 million hectares in Thailand with average rubber yield (2002-2012) as high as 690.5 kilograms per acre (Thailand Office of Agricultural Economics, 2012).

Thailand leads the world in production and exporting of rubber, with production in 2011 of 3.57 million tons, which is 33.48 percent of the world's production of 10.66 million tons. Thailand is followed by Indonesia with a production of 2.89 million tons and Malaysia with 1.02 million tons. Thailand exported 2.95 million tons (about 83% of the country's production) which is 36.42 percent of the world's exportations of 8.10 million tons, generating 22,631,000 US$ (Rubber Research Institute of Thailand, 2012).

The south of Thailand is where the most area of natural rubber is grown, followed by the northeast, east and north, respectively. Rubber plantations have doubled from 540,000 farms to 1.16 million farms. This is especially true in the northeast of Thailand, the newly developed growing area, where in the last 10 years plantations have continuously increased the rubber plantation growing area 7 times more than previously (National Statistical Office of Thailand, 2013). This has caused an increase in rubber output to the market.

Due to trends that affect rubber production in Thailand, rubber is a major exporting crop. Thailand is now the world's largest rubber producer. Rubber production in Thailand range between 3.7 and 3.8 million tons a year and most of the

[2] Rai is a unit of area, generally used in Thailand; 1 Rai = 0.16 Hectare.

production are exported, which account for 3.1 million tons (about 83%), while only 505,052 tons are consumed domestically (only 13%). With trade liberalization, Thailand is a world price taker. Currently, Thai natural rubber farmers suffer from falling prices. The government has given an explanation about the problem of falling rubber prices in 2012. Limlamthong, Deputy Prime Minister and Minister of Agriculture and Cooperatives said, “The global economic slump over the past two years has affected Thailand’s rubber exports” (The government public relations department of Thailand, 2013). Rubber supply in the world stands at 11.6 million tons; nevertheless, only 11.1 million tons have been used. So the oversupply has led to falling prices.

In Thailand the agricultural sector has gone through various policies which have affected both the factor and product markets resulting in changes in the structure of the market. Traditionally, rubber production absorbs aftershocks from related economic problems. The price of rubber decreases due to oversupply. In the past, the Thai government insured standard prices in order to assist the farmers. However, an insured standard price per kilogram of raw pieces of Para rubber (Natural rubber) isn’t a sustainable solution. The sustainable solution is to control the production volume in accordance with the requirements of the market (Chareonwongsak, 2013). So it is crucial to understand what factors affect rubber production and in what ways.

This study hence pursues the demand and supply response framework of analysis to examine the dynamics of the demand and supply of rubber in Thailand. Effort in this direction will have to be done through analysis of the factors that affect the demand and supply of rubber.

Problem Statement

From past literature, there are very few studies that have examined the demand and supply equations simultaneously and the results where the last study was done in 1987 are dated. Therefore a new model needs to be formed to be able to analyze the rubber market.

Hypothesis

1) A positive and elastic relationship exists between rubber demand with the U.S. GDP per capita, a positive and inelastic relationship exists between rubber demand with U.S. vehicle sales, and a negative and elastic relationship exists between rubber demand with the price of ribbed smoked sheet rubber in the demand model.

2) A positive and elastic relationship exists between rubber supply with the price of ribbed smoked sheet rubber, and a negative and elastic relationship exists between rubber supply with the rice price and rainfall in the supply model.

Objectives

1) To estimate the econometric model of demand and supply of natural rubber in Thailand.

2) To determine if a relationship exists between the demand and supply of rubber and its determinants.

Justification

The natural rubber industry has affected Thai farming households, which includes more than 6 million individuals comprised of small rubber farmers, laborers and downstream industries (Rubber Research Institute of Thailand, 2012). The natural rubber industry has contributed to Thailand's economic development and industrialization, and is a major exporting crop.

The "rubber-rush" era, with economic incentive, has become a trend for people to alleviate poverty. Without a plan for production, when the price is high, the incentive has drawn investors and growers to expanding planted area and increase rubber production. However, when the price falls it has become a big issue for the country.

The results of this study will enable rubber producers to get a better understanding of factors that influence the rubber market. Therefore rubber producers can adjust their production plan by handling change (shock) of the factors, such as the price of ribbed smoked sheet rubber, alternative crops prices and rainfall. Also, the rubber industry can estimate and better prepare the supply response for rubber production in Thailand. Moreover, policy makers can develop policy that takes into consideration possible shocks to one of the factors, enabling them to better forecast, plan and maximize rubber supply production in Thailand.

Chapter 2

REVIEW OF THE LITERATURE

This literature review of natural rubber covers a wide range of subjects. First, it reviews the previous studies, which is research on rubber and other agriculture product. Secondly, it reviews econometric approaches to agricultural demand and supply responses by describing the simultaneous equations model, describing the instrumental variables estimation by two-stage least squares, and reviews research papers that choose the instrumental variables estimation by two-stage least squares to analyze demand and supply.

Research on Rubber

The previous research on rubber is an important topic; its main aim is to derive models, estimation methods, and results for use in developing our model in this study. One study on rubber demand by Jaitung (2011) used natural rubber price, oil price, exchange rate, nominal effective exchange rate (Baht Index), GDP of China, U.S. and Japan as factors to study the rubber demand of Thailand. This study used a cointegration methodology by Engle and Granger to study the relationship. The results concluded that the rubber price, nominal effective exchange rate (Baht Index), and gross domestic product (GDP) of China have a negative relationship with rubber demand in Thailand. Oil price, exchange rate, and GDP of U.S. and Japan have a positive relationship. This study stated the relationship of each variable with demand of rubber. However, this study did not analyze the reasons why it has a positive or a negative relationship (e.g. between GDP of the three countries above, why they have different relationship with the demand of rubber since they are all major import countries for Thai rubber). There was no testing for a multicollinearity problem that may exist.

Manachotipong (2012) estimated the elasticity of demand for exported rubber products and income (GDP) elasticity of demand for trade partners imported rubber products. This study used instrumental variable estimation method with panel data from January 2001 to July 2012. The results showed the elasticity of demand for exported rubber products that was not very high, which means if the price of rubber increases 1 percent the demand for rubber from Thailand will decrease less than 1 percent. However, the results showed a high elasticity of income (GDP) of demand for trade partners (countries), especially in the area of tires that are mostly used in the automotive industry. When the GDP increased, the growth in the economy increased resulting in benefits to the industry in the country. As a result, the automotive industry is expanding, so the rubber demand increases accordingly. Therefore, an increase in GDP will benefit automotive sales and tires as well. If GDP of the trade partners decrease 1 percent, the demand for rubber from Thailand will decrease more than 1 percent. Therefore, economy of the trade partners cannot be overlooked and need to be main factors to analyze the policy for export rubber.

In previous research on rubber supply, Purcell (1993) studied the factors affecting the rubber supply from Sarawak by using a cointegration method and causality tests to determine the relationship between rubber production, price, area, and labor. The results showed that rubber supply was affected by the area planted to rubber and price. The area planted for rubber is affected by price and labor factors. Prices have affected the rubber supply. These results can be used as a guide in a reflection of global supply trends affecting prices.

Much, Tongpan and Sirisupluxana (2013) analyzed the supply response for natural rubber in Cambodia by using partial adjustment and adaptive expectation mechanism. The rubber planted area and rubber yield are set as supply response in their study. They used rubber prices from the last two years (year t-2), alternative crop prices (maize), and planted area in the previous year as independent variables in acreage response model. They used rubber prices in the previous year, alternative crop prices (cassava), actual rainfall, and rubber yield in the previous year as independent variables in the yield response model. The finding showed that the expansion of rubber area planted, improvement in the rubber yield and rubber supply are affected by rubber price, rainfall and alternative crop prices. Other factors such as the planted area in the previous year and rubber yield in the previous year also relate to rubber supply. The rubber cultivator responsiveness to the natural rubber price was inelastic in the short- run but elastic in the long- run. They recommended that in order to increase rubber production, the rubber growers should be motivated by improved technology that increases rubber yield.

Mesike and Esekhade (2014) studied the rainfall variability and rubber production in Nigeria. This study determines the rainfall variability and its effect on the rubber production. The results showed that there is a negative relationship between rubber production and rainfall. Rubber production was normally low during the rainy season. Thus, the seasonal changes are important determinants influencing the market (“Rubber seasonal report,” 2010).

Mesike, Okoh and Inoni (2010) studied the supply response of rubber farmers to prices (vector of producers’ prices, vector of export prices) and other factors (output at different times, exchange rate, time trend and structural breaks) in Nigeria. The cointegration and vector error correction techniques were used to analyze the time series data. The result showed that rubber supply had a positive relationship with the producer's price and structural break.

Kannan (2013) examined the determinants of production and export of natural rubber in India. This study used the Ordinary Least Squares (OLS) method to determine the various factors such as export quantity, import, stock, domestic price and rainfall. The results showed that the natural rubber export quantity, rubber price and stock of rubber have a positive relationship with the natural rubber production. However, rainfall and natural rubber import quantity are not significant in India.

Moreover, there are also researchers who study the rubber export, such as Abolagba et al. (2010) who studied the factors that influence agricultural exports with specific reference to cocoa and rubber in Nigeria. Natural rubber quantity output (rubber supply), producer's price, world price, domestic consumption and interest rate were used in the Ordinary Least Squares method to find the effect on natural rubber export quantity. The results showed that rubber export had a positive relationship with domestic rubber production, producer price and interest rate. On the other hand, the results showed a negative relationship with exchange rate and domestic consumption.

Amoro and Shen (2013) studied the determinants of cocoa and rubber for the Ivory Coast. This study used the same model and methodology as Abolagba et al. (2010). The results from the Ordinary Least Squares revealed that rubber was influenced significantly and had a positive sign for domestic rubber production, producer price and interest rate. The same Ordinary Least Squares results had a negative sign for exchange rate and domestic consumption, and were influenced significantly.

Studying supply without also looking at the demand (or study the demand without also looking at the supply) takes a chance of missing important linkages and thus making significant mistakes (Studenmund as cited in Vittetoe, 2009). One study of the simultaneous demand and supply of rubber was done by Suwanakul and Wailes (1987). They estimated structural relationships for the world's rubber market with particular emphasis on Thailand's natural rubber industry. This study utilized annual data from 1954-1983, and used the two-stage least squares (2SLS) method to analyze the simultaneous equations. This study focused on price elasticity. The advantage of this study was to describe the price elasticity of demand and supply of rubber in the different areas. For the supply function, rubber area planted, rubber yield, Thailand's rubber production, world's rubber production, rest of the world's rubber production and natural rubber export were used to study the relationship of the price elasticity. On the demand side, Thai rubber consumption, U.S. rubber consumption, world rubber consumption, rest of the world's rubber consumption and U.S. natural rubber import were used to study the relationship of the price elasticity. The results of this study showed that the price elasticity of natural rubber in the long-run is higher than the short-run. However, the disadvantage in this study was that there was no explanation for the effects of other independent variables[3] on each dependent variable (only explanation for price). They did not test for a multicollinearity problem and for an autocorrelation problem, which may have led to unreliable and unstable estimates of regression coefficients.

Research on the Other Agriculture Products

Research on other agricultural product prices such as cotton, peaches, pepper, durian, pineapple and rice were studied. Other factors such as alternative crop prices relative to competing crops and rainfall were also reviewed.

[3] Independent variable is a variable that is manipulated to determine the value of dependent variables.

In terms of response to price on other agricultural production, Mehregan et al. (2013) investigated the response of cotton under cultivated area in Golestan province of Iran. The Nerlove's partial adjustment method was applied in order to assess the response of cotton to wheat under cultivated areas during the period of 1983- 2012. The results showed that the global prices for cotton and wheat self-sufficiency ratio had a significant effect on cotton cultivation. Moreover, many previous researchers such as Laajimi et al. (2008), Earamnouy (2005), Samatee (2006) and Amnutkittikul (2003) reached a similar conclusion. The results of these studies showed that price was the factor affecting the change of planted area and yields in the same direction. Thus, it can be concluded that farmers respond to higher or lower prices in their production by raising their output in response to higher prices and reducing output during low prices. This means price factor can be affected by quantity of production (Nyairo, Kola and Sumelius, 2013).

Apart from the price factor, there are also the other factors that can affect agricultural production. Alternative crops prices are one of the factors that can affect agricultural production. Theoretically, competition between crops for land area exists. When the prices of alternative crops increase, the quantity of competing crops decrease because more land is allocated to other crops (Soontaranurak, 2011). Molua (2010) studied how rice production contributes to income and welfare of producers in Cameroon by using the Engle and Granger cointegration method. The results revealed that rice yield had a positive relationship with producer's prices of rice in relation to global prices of rice, governmental expenditure for agriculture and irrigation. On the other hand, rice yield had a negative relationship with producer's price of rice in relation to producer's price of maize. Mushtaq and Dawson (2003) studied the yield response in Pakistan agriculture by using the cointegration method. The results of this study revealed that wheat supply had a negative relationship with the prices of cotton. This meant that alternative crop price (cotton) affected wheat production in the opposite direction.

Furthermore, rainfall is also one of the factors that can affect agricultural production. In the study of supply response of peaches in Tunisia, rainfall is positively related to yield level (Laajimi et al., 2008). However, high rainfall for a long period can also have a negative impact on crops yield. An excess rainfall may lead to problems associated with waterlogging; moreover, it may cause nutrient erosion and dilution of the land. As a result, higher rainfall led to a reduction in crop production (Land Development Department, 2011). Moreover, there are also other factors such as fertilizer price and labor. Amnutkittikul (2003), Earamnouy (2005), Samatee (2006) and Olujenyo (2008) concluded that the fertilizer price and labor factors affect the crop prices more than the production.

Econometric Approaches to Agricultural Demand and Supply Response

In conducting this study, the two-stage least squares method is used in order to solve the demand and supply systematic equations. This section will review research papers that chose the instrumental variables estimation by two-stage least squares to analyze demand and supply.

The previous research on rubber and other agricultural production that was mentioned above focused only on the demand or supply. Ordinary least squares regression is one of the most popular statistical techniques used in the study of agricultural product. It is used to predict values and identify relationships of a continuous response variable using one or more explanatory variables[4] (Hutcheson and Sofroniou, 1999). However, the results from the ordinary least squares will not be accurate in the simultaneous equations, because they are missing the instrumental variables that one equation can have an effect on another equation. So, the instrumental variables estimation by two-stage least squares method will be used to solve and analyze the simultaneous equations of rubber in this study.

1. Simultaneous Equations

The simultaneous equations model is the model that has one or more of the explanatory variables jointly determined with the dependent variable. Each equation in a simultaneous equations model should described how one or more economic agents will react to shocks or shifts in the exogenous variables, ceteris paribus. The simultaneously determined variables often have an equilibrium equation, and these variables are only observed when the underlying model is in equilibrium (Wooldridge, 2012). When using the ordinary least squares method to estimate the structural equation without regard to the other equations (e.g. estimate demand equation without regard to supply equation), the results will yield a biased and inconsistent coefficient value. This problem is caused by an endogenous explanatory variable that is correlated with the error term (Cold and Cold, 2007). To avoid simultaneous equation bias, two-stage least squares method will be used to estimate the simultaneous equations in this study (Oyamakin, Fajemila and Abdullateef, 2013).

2. Instrumental Variables Estimation by Two-Stage Least Squares

The method of instrumental variables was first used in the1920s to estimate supply and demand elasticities, and later used to correct for measurement error in single equation models (Angrist and Krueger, 2001). In the situation where some

[4] Explanatory variable has the same meaning to independent variable, which is a variable that is manipulated to determine the value of dependent variables.

explanatory variables correlated with the error term, ordinary least squares will fail to provide consistent estimates. Thus, instrumental variables estimation by two-stage least squares will be used to provide the consistent estimates for linear regression models. The instrumental variables estimation by two-stage least squares involves using Ordinary Least Squares regression in two-stages. This allows for avoiding the endogeneity problem and solve for the structural equations. In stage one, an ordinary least squares prediction of the instrumental variable is obtained from regressing it on the instrumental variables. In stage two, the coefficients of interest are estimated using ordinary least squares after substituting the instrumental variable by its predictions from stage one (Imai, King and Lau, 2008). Thus, the instrumental variables estimation by two-stage least squares will be used to calculate the demand and supply equations in this study.

Similarly, numerous studies have used instrumental variables estimation by two-stage least squares method to analyze the simultaneous equations model such as Åström (2013) who studied supply and demand of the silver market. The annual data from 1973-2011 was used. This study starts with a multicollinearity test to avoid the unreliable and unstable estimates of regression coefficients. Next, it used the instrumental variables estimation by two-stage least squares method to avoid the endogeneity problem and solve for the supply and demand while checking for the autocorrelation problem by a Durbin-Watson test. The results showed that the estimated price has a positive relationship with supply of silver but has no significant value. But the other exogenous variables are all significant in the supply model (U.S. real interest rate, price of oil, price of base metals and technological development). In the demand model, the estimated price has a significant positive relationship with demand of silver and the other exogenous variables are all significant in the demand model (U.S. industrial production index, U.S. dollar index, U.S. adjusted monetary base and technological development). It can be concluded that price is not necessarily significant in both demand and supply model.

There are also studies that use the instrumental variables estimation by two-stage least squares method to solve and analyze demand or supply. Specifically, Zhou (2011) studied market power in the Dutch coffee market from 1990-1996. He focused on the demand equation. The instrumental variables estimation by two-stage least squares was used to analyze the degree of market power in the Dutch coffee industry and avoids the endogeneity problem. Likewise, to avoid the endogeneity problem, researchers such as Chang (2010), Jahan, Abdullah and Viswanathan (2001), Van der Sluis and Peterson (1998) and Tuzun (2002) all used the instrumental variables estimation by two-stage least squares to solve the simultaneous equations in their research.

Chapter 3

METHODOLOGY

To derive simultaneous equation models of natural rubber in Thailand, demand and supply of natural rubber in Thailand are formed. The following endogenous[5] and exogenous[6] variables are collected: quantity of natural rubber in Thailand, price of ribbed smoked sheet rubber, the U.S. GDP per capita, U.S. vehicle sales, rice price, and rainfall. The data contained in the study is secondary annual time series data from 1977-2012. Data was procured from Thailand Office of Agricultural Economics (OAE), Bank of Thailand, Ward's Automotive Group (WardsAuto), Food and Agriculture Organization of the United Nations (FAO) and World Bank. The following section presents the procedures for data collection and methodology of the study.

Procedures for Data Collection

The specification of the simultaneous equations model of natural rubber in Thailand are based on the literature review. This paper creates the model that can state the simultaneous equation models of natural rubber in Thailand by using both endogenous and exogenous variables. However, with the limitation of data, the form of simultaneous equation functions of natural rubber used in this study takes the following form:

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[5] Endogenous variables are dependent variables, i.e., they are determined within the system of equations (Q_t and P_t) that correlate with the error term (McFadden, 1999).
[6] Exogenous variables are independent variables, which are determined outside the system, or functionally, are uncorrelated with the disturbances of both equation ($\mathcal{E}_t$ and μ_t) (McFadden, 1999).

Rubber Demand functions:

$$\text{Rubberq}_t^D = f(\text{Rubberp}_t, \text{USAGDP}_t, \text{USCarsales}_t, \varepsilon_t)$$

Rubber Supply functions:

$$\text{Rubberq}_t^S = f(\text{Rubberp}_t, \text{Ricep}_t, \text{Rainfall}_t, \mu_t)$$

Table 3.1 Description of data and sources

Variable	Definition	Source
	Endogenous variables	
Rubberq_t^D	Total quantity of natural rubber demand (MT)[7]	FAO
Rubberq_t^S	Total quantity of natural rubber supply (MT)	FAO
Rubberp_t	RSS3 price (US$/MT)[8]	OAE
	Exogenous variables	
USAGDP_t	The U.S. GDP per capita (current US$)	World Bank
USCarsales_t	U.S. Vehicle Sales	WardsAuto
Ricep_t	Rice price (US$/MT)	Bank of Thailand
Rainfall_t	Average rainfall (mm)[9]	OAE
ε_t, μ_t	the random disturbance term	

The endogenous variables in this study are quantity and price of rubber. Rubberq_t^D is the total quantity of natural rubber demand that the world consumed from Thailand including domestic consumption. These values were obtained by assuming the market is in equilibrium meaning that supply quantity always equals demand quantity. Rubberq_t^S is the total quantity of Thailand's natural rubber production.

The price of ribbed smoked sheet rubber in Thailand is assumed to be representative of the price of rubber (Rubberp_t) in Thailand because until 2004 rubber

[7] MT = metric ton is a metric system unit of mass equal to 1,000 kilograms.
[8] US$/MT = United States dollar per metric ton.
[9] mm = millimeters. A rain gauge, measures the amount of liquid precipitation that falls. It can measure either rain or, with added steps, the liquid equivalent of snow. Most rain gauges generally measure the precipitation in millimeters ("Rain Gauge," n.d.).

ribbed smoked sheet (RSS) was the most exported type of product. Theory suggests that the price of rubber has a negative relationship with the quantity demanded of rubber and a positive relationship with the quantity supplied of rubber. When the price of rubber is low it results in more demand. However, when the price of rubber is high it results in more production. This data was converted from Thai Baht currency to US dollars, by using the data in year t in Thai Baht currency divided by the annual exchange rate[10] data (Baht /US$) in year t.

Exogenous variables selection in this study started with looking to the previous studies and journal articles. In demand models, Jaitung (2011) and Manachotipong (2012) used GDP of China, U.S. and Japan as factors to study the rubber demand of Thailand, because China, U.S and Japan are major markets for Thailand. Moreover, the GDP per capita can be used as an indicator of standard of living ("Per Capita GDP," n.d.). When the GDP per capita increased, the growth in the economy is increased as well. Thus, an increase in the GDP per capita will benefit automotive sales and production in that country (Asia-Pacific Economic Cooperation, n.d.). Suwanakul and Wailes (1987) suggest that U.S. is the most important rubber consuming country.

Variable $USAGDP_t$ in this study is the U.S. GDP per capita (current US$). Thailand exports natural rubber to various countries. U.S. is the 3rd by quantity (1st and 2nd are China and Japan, but they have no significance to the demand of rubber in Thailand)[11]. Thus, the U.S. GDP per capita should have a positive relationship with rubber demand.

U.S. vehicle sales ($USCarsales_t$) is the factor that can affect rubber demand in Thailand. The U.S. is the 2nd largest vehicle selling country in the world (OICA, n.d.).

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[10] Annual exchange rate that convert US$ to THB from the year 1977-2012 ("Yearly Average Rates," n.d.).

[11] Appendix 3

Vehicle sales can affect the vehicle production in the same direction. Rubber products are mainly used in the automotive industry. When the automotive industry is expanding the rubber demand increases accordingly.

In supply models from previous studies, numerous researchers such as Much, Tongpan and Sirisupluxana (2013) used alternative crop prices in their study. Theoretically, competition between crops for land area exists. In Thailand, rice is an alternative crop for rubber (Kumpeera et al., 2008). Some rice and other crop lands switched to rubber since rubber was more profitable (Wachiradetwong, 2011). Kumpeera, et al. (2008) studied SPOT–5 Satellite images to examine the land use changes from paddy fields into other cash crop plantations and economic valuation in the Phatthalung Province of Thailand. The result from 2002 to 2007 showed that paddy fields have reduced by 29.13 percent and transformed into Para rubber area by 24.13 percent. These changes of paddy fields into other cash crop plantations result from weather and the price of rubber. If the price of rubber were increased farmers would switch to rubber production (Rongdate, 2008).

In this study, variable $Ricep_t$ is the rice price (US$/MT). Rice price should have a negative relationship with rubber supply. This data was converted from Thai Baht currency to US dollars, by using the data in year t in Thai Baht currency divided by the annual exchange rate data (Baht /US$) in year t.

There are researchers who use rainfall in their studies, such as Mesike and Esekhade (2014) and Kannan (2013). Rainfall represents input for rubber production; it is a dominant controlling variable in rubber plantation because it supplies soil moisture and soil nutrients. Thus, it will facilitate the growing of rubber.

The variable $Rainfall_t$ is the average rainfall (mm). In this study only the rainfall that was measured in the southern part of Thailand is used which is the main rubber production area in Thailand. This factor should show a negative relationship with supply because heavy rains cause farmers not to harvest rubber.

Procedures for Data Analysis

The econometric analysis conducted herein consists of four parts. Initially, the condition for identification will be determined to see whether the two-stage least squares approach can be used to solve the problem. Secondly, the multicollinearity test will be used with each of the exogenous variables considered, to avoid the unreliable and unstable estimates of regression coefficients. Thirdly, the instrumental variables estimation by two-stage least squares will be used in order to solve the demand and supply system. A Durbin-Watson test will be used to check to see if there is an autocorrelation problem in the regression analysis. If an autocorrelation problem exists, the estimates will be inefficient (not least variance), which causes the model to fit the data better than it actually does (easily becomes significant). Lastly, a Durbin-Wu-Hausman test will be used to check for the existence of endogeneity problem. All tests were performed using the EViews[12] 8 econometric software from Quantitative Micro Software, LLC, 2013. The details of these four parts are as follows:

1. Condition for Identification

In order for an equation to be identified in a complete system of simultaneous equations, the number of all variables in the system exclude the variables in the considered equation must not be less than the number of endogenous variables in the considered equation subtracted by one. This is known as the order condition of identifiability. When simultaneous equations are identified, Two-Stage Least Squares

[12] EViews is a statistical package for Windows, used mainly for time-series oriented econometric analysis. It is developed by Quantitative Micro Software (QMS). The current version of EViews is 8.0, released in March 2013.

method can be performed (Gujarati, 2003). A mathematical formulation of the order condition is the following:

$$K - k \geq m - 1$$

Where:

K is number of all variables in the system

k is number of all variables in the considered equation

m is number of endogenous variables in the considered equation

2. Multicollinearity Test

Multicollinearity is a statistical phenomenon in which two or more independent variables in a multiple regression model are highly correlated. Multicollinearity leads to high variance of coefficients that may reduce the precision and can result in coefficients appearing with the wrong sign of estimation. Thus, multicollinearity is a serious problem that needs to be avoided (El-Dereny and Rashwan, 2011). The variance inflation factor (VIF) assesses the effect of multicollinearity in an ordinary least squares regression analysis. It provides a value that measures how much the variance of an estimated regression coefficient is increased because of multicollinearity.

To test for Multicollinearity there are two steps follow:

The first step is to run an ordinary least squares regression between exogenous variables.

$$lnUSAGDP_t = f(lnUSCarsales_t, lnRicep_t, lnRainfall_t, \text{ƻ}_t) \quad (1)$$

$$lnUSCarsales_t = f(lnUSAGDP_t, lnRicep_t, lnRainfall_t, \prod_t) \quad (2)$$

$$lnRainfall_t = f(lnRicep_t, lnUSAGDP_t, lnUSCarsales_t, \Psi_t) \quad (3)$$

$$lnRicep_t = f(lnRainfall_t, lnUSAGDP_t, lnUSCarsales_t, \cap_t) \quad (4)$$

ε, $\prod$, Ψ, $\cap$ is the random disturbance term

The second step is to calculate the VIF factor with the following formula:

$$VIF = 1/(1-R^2)$$

Where:

R^2 is R-squared value from the ordinary least squares regression, which is indicates how well data points fit a statistical model

The magnitude of multicollinearity can be analyzed by considering the size of the VIF; if VIF value exceeds 5, then the variable is considered to have a multicollinearity problem (Montgomery and Peck as cited in Cropper, 1984).

3. Instrumental Variables Estimation by Two-Stage Least Squares and Autocorrelation Test

Simultaneous equations

When using the ordinary least squares method to estimate the structural equation without regard to the other equations, the results will yield a biased and inconsistent estimator. To avoid simultaneous equation bias, the two-stage least squares method will be used to estimate the simultaneous equations in this study (Oyamakin, Fajemila and Abdullateef, 2013).

The general form of structural simultaneous equations (5) and (6) are constructed; one that explains demand and another that explains supply. We use Z^D to indicate that this variable is exogenous in demand model (5) and use Z^S to indicate that this variable is exogenous in supply model (6). The important point is that without including Z^D and Z^S in the model, there is no way to tell which equation is the demand equation or supply equation (Wooldridge, 2012). The disturbances ε_t and μ_t reflect the impact of various unmeasured factors on demand and supply, respectively.

General Form of Structural Equations:

Demand Model $Q^D_t = \boldsymbol{\alpha_0} + \boldsymbol{\alpha_1}P_t + \boldsymbol{\alpha_2}Z^D_t + \mathcal{E}_t$ (5)

Supply Model $Q^S_t = \boldsymbol{\beta_0} + \boldsymbol{\beta_1}P_t + \boldsymbol{\beta_2}Z^S_t + \mu_t$ (6)

Equilibrium equation (7) is an equation that describes structural equilibria in the economic systems, which assuming the market is in equilibrium, means that supply quantity always equals demand quantity. The best known equilibrium equation in economics is as follows:

$$Q^D_t = Q^S_t = Q_t \quad (7)$$

In order to be able to interpret the coefficients of the equations as elasticities, the variables are transformed into natural logarithmic form. Double Log models will be used in this study. Double Log models are invariant to the scale of the variables since they measure percent changes. They give a direct estimate of elasticity. The distribution of dependent variables is narrower, limiting the effect of outliers. The types of variables that are often used in log form are measured in years, data in proportion or percent, and very large data (Kawabata, n.d.).

Demand equation:

$$\text{lnRubberq}_t^D = \beta_0 + \beta_1\text{lnRubberp}_t + \beta_2\text{lnUSAGDP}_t + \beta_3\text{lnUSCarsales}_t + \mathcal{E}_t \quad (8)$$

Supply equation:

$$\text{lnRubberq}_t^S = \gamma_0 + \gamma_1\text{lnRubberp}_t + \gamma_2\text{lnRicep}_t + \gamma_3\text{lnRainfall}_t + \mu_t \quad (9)$$

Equilibrium equation:

$$\text{lnRubberq}_t^D = \text{lnRubberq}_t^S = \text{lnRubberq}_t \quad (10)$$

In demand equation (8), lnRubberq_t^D is the natural logarithm of total quantity of natural rubber demand; lnRubberp_t is natural logarithm of RSS3 price; lnUSAGDP_t

is natural logarithm of the U.S. GDP per capita; $lnUSCarsales_t$ is natural logarithm of total U.S. Vehicle Sales; and ε_t is the random disturbance term.

In supply equation (9), $lnRubberq_t^S$ is natural logarithm of total quantity of natural rubber supply; $lnRubberp_t$ is natural logarithm of RSS3 price; $lnRicep_t$ is natural logarithm of rice; $lnRainfall_t$ is natural logarithm of average rainfall; and μ_t is the random disturbance term.

In equilibrium equation (10), the natural logarithm of total quantity of natural rubber demand ($lnRubberq_t^D$) is equal to the natural logarithm of total quantity of natural rubber supply ($lnRubberq_t^S$).

Instrumental Variables Estimation by Two-Stage Least Squares

As the name suggests, instrumental variables estimation by two-stage least squares involves using Ordinary Least Squares regression in two-stages. It avoids the endogeneity problem and solves for the demand and supply system. In the first stage, a reduced form of the structural equations is estimated where the endogenous variable is regressed on all the exogenous variables in the system. This generates a new variable that estimates the endogenous variable, which is creating the bias problem. In the second stage, the structural models are estimated using the endogenous variable from first stage. The transformed structural equations are then regressed to obtain consistent and unbiased estimates of the equations (Åström, 2013).

First Stage

In the first stage of two-stage least squares the variable that is creating the problem (original endogenous explanatory variable that creates the bias problem), is determined which in this study is $lnRubberp_t$. The ordinary least squares estimation procedure is used to estimate the $lnRubberp_t$. All exogenous variables in the equation system are used as instrumental variables to estimate the reduced form of equilibrium price equation. In general, this is accomplished regressing $lnRubberp_t$ on all instrumental variables in the equation system (Wooldridge, 2012).

Equilibrium price equation[13]*:*

$$lnRubberp_t = \alpha_0 + \alpha_1 lnUSAGDP_t + \alpha_2 lnUSCarsales_t + \alpha_3 lnRicep_t + \alpha_4 lnRainfall_t + \mho_t \quad (11)$$

After estimating the equilibrium price model, a new variable (lnEstp) is generated that estimates the price of rubber based on the first stage.

Second Stage

In the second stage, the structural models are estimated by using the instrumental variable of the “problem” explanatory endogenous variable (lnEstp) by substituting the rubber price variable (lnRubberp) with lnEstp in the structural equations (8) and (9). Then, the ordinary least squares estimation procedure is used to estimate the structural models as follows:

Demand equation:

$$lnRubberq_t^D = \beta_0 + \beta_1 lnEstp_t + \beta_2 lnUSAGDP_t + \beta_3 lnUSCarsales_t + \varepsilon_t \quad (12)$$

Supply equation:

$$lnRubberq_t^S = \gamma_0 + \gamma_1 lnEstp_t + \gamma_2 lnRicep_t + \gamma_3 lnRainfall_t + \mu_t \quad (13)$$

These regressions of the transformed structural equations (equation (12) and (13)) are consistent and unbiased estimates of the variables affecting demand and supply of rubber. Thus, the simultaneous equations model is appropriate when separate equations describe different sides of a market and when each equation in the system has a ceteris paribus[14] interpretation.

[13] Appendix 2
[14] Ceteris paribus mean “all things being equal”, in this study assuming the market is in equilibrium, means that supply quantity always equals demand quantity

Autocorrelation Problem

Autocorrelation, sometimes called "serial correlation," refers to the correlation of a time series, where the current residual (u_t) is correlated with a past residual (u_{t-s}). Autocorrelation will make the model unreliable, because the results from estimation cause the variables to easily become significant. If autocorrelation is present, then:

$$Cov(u_t,u_{t-s}) = E(u_t,u_{t-s}) \neq 0 \text{ for } s > 0$$

That is the error for the period "t" which is correlated with the error for the period "t-s". For example, if s = 1 it mean the current residual (u_t) is correlated with the residual from the previous year (u_{t-1}).

Durbin-Watson Test

The Durbin-Watson (DW) Test is responsible for ensuring the null hypothesis (no first-order autocorrelation) that the residuals from an ordinary least squares regression are not autocorrelated with the residuals of first order autoregressive[15] process. The Durbin-Watson statistic ranges in value from 0 to 4. A value near 2 indicates no autocorrelation, a value toward 0 indicates a positive autocorrelation; a value toward 4 indicates a negative autocorrelation. The DW statistic can be calculated by the following:

$$DW = \sum(u_t - u_{t-1})^2 / \sum u_t^2$$

The values d_U and d_L (upper and lower critical values) can be found from Durbin-Watson Significance Tables, when n = amount of sample and k= number of regressors excluding the intercept. The result of the test can be stated in following ways:

[15] Autoregressive describes a stochastic process that can be described by a weighted sum of its previous values and a white noise error. An AR(1) process is a first order one process, meaning that only the immediately previous value has a direct effect on the current value ("Definition of Autoregressive," n.d.).

Table 3.2 Durbin-Watson Test criterion

Condition	Results
$0 < DW < d_L$	Positive autocorrelation
$d_L < DW < d_U$	Inconclusive
$4\text{-}d_L < DW < 4$	Negative autocorrelation
$4\text{-}d_U < DW < 4\text{-}d_L$	Inconclusive
$d_U < DW < 4\text{-}d_L$	No autocorrelation

Solution of autocorrelation problem

After testing the autocorrelation problem, the results show that the model has an autocorrelation problem. Ordinary Least Squares is not BLUE[16] when errors are serially correlated. The simplest way to solve this problem in EViews software, is to add an AR(1) variable as an additional independent variable to transform the original autoregressive error term into one with a non-correlated error term. If the model still has an autocorrelation problem, just add the higher order of Autoregressive. The AR(p) model is as follows:

$$y_t = \mu_y + \sum_{i=1}^{p}[\text{Ø}_i(y_{t-i} - \mu_y)] + \varepsilon_t \qquad ; p = 1, 2 \ldots t$$

Where:

y_t represents the output at time t

μ_y is a constant

Ø_i is the coefficients of the model

ε_t is a white noise term with zero mean

p is the order of the model

[16] The term best linear unbiased estimator (BLUE) comes from application of the general notion of unbiased and efficient estimation in the context of linear estimation (Wood and Park, 2004).

4. Endogeneity Test

When estimating the demand and supply equations, the problem of endogeneity occurs when the equations consists of two endogenous variables: price (Rubberp) and quantity (Rubberq). These two variables are determined simultaneously inside the equation system where price affects quantity and quantity affects price. A common approach to handle problems like this is to use a regression technique called two-stage least squares. By applying two-stage least squares regression, consistent and unbiased estimates of the equations can be obtained (Brooks, 2008).

Durbin-Wu-Hausman Test can be used to check for the existence of endogeneity (Stock and Watson, 2002). The endogeneity problem test procedure is as follows:

1) Estimate the reduced form equation of equilibrium price model from the first stage and get the residuals[17] (RESID01).

2) Add RESID01 as an additional explanatory variable in the structural model.

3) Estimate the structural models - if coefficient of RESID01 is statistically significant, the model has endogeneity problem.

Assumptions and Limitations

The accessibility to appropriate historical data is limited. To provide significant results from the available data, the models are developed to fit with the accessible data. In the initial selection of variables, the China and Japan GDP per capita were used in the econometric model in this study, but were found to be insignificant and also made all the variables in the model insignificant. Also, China

[17] There are many ways to get residuals. In this study using Eviews 8 software to gets residuals, by choosing View/Residual Test/Correlogram-Q-Statistic in Toolbars.

and Japan's GDP are highly correlated with the U.S. GDP, which would cause a multicollinearity problem in the model[18]. So, these variables were left out of the models. However, after searching for a better model, the U.S. GDP per capita became the better variable to use in the model.

It can be argued that labor wages should be in the supply equation. In terms of the labor factor, the wages for rubber workers are unlike the other types of wage employment. The labor system for rubber farmers in Thailand has adopted an output sharing system where tappers earn income by sharing output income with owners (in a 50-50, 60-40, 70-30 split.). Since the wages of rubber depends on the rubber price and yield, implying there is no fixed wage per hour of work, the available national data regarding worker wages do not make sense to use as an explanatory variable.

[18] Appendix 3

Chapter 4

RESULTS AND ANALYSIS

In this chapter, the results and analysis of the simultaneous equations will be provided based on the procedure for data analysis in the previous chapter.

Condition for Identification

The condition for identification will be used to determine whether the two-stage least squares approach can be used to solve the problem. The condition was checked for identification in the demand and supply model as follows.

In demand model, the number of all variables in the system (K) is 6 ($Rubberq_t^D$, $Rubberp_t$, $USAGDP_t$, $USCarsales_{t,}$ $Ricep_t$, and $Rainfall_t$). The number of variables in the demand equation (k) is 4 ($Rubberq_t^D$, $Rubberp_t$, $USAGDP_t$, and USCarsales). The number of endogenous variables in the demand equation (m) is 2 ($Rubberq_t^D$ and $Rubberp_t$). A mathematical formulation of the order condition is the following:

$$6-4 \geq 2-1$$

$$2 \geq 1$$

From the condition for identification, the number of all variables in the system excluding the variables in the demand equation is greater than the number of endogenous variables in the demand equation subtracted by one. Thus, the demand model is identified.

In supply model, the number of all variables in the system (K) is 6($Rubberq_t^S$, $Rubberp_t$, $USAGDP_t$, $USCarsales_{t,}$ $Ricep_t$, and $Rainfall_t$). The number of variables in the supply equation (k) is 4 ($Rubberq_t^S$, $Rubberp_t$, $Ricep_t$, and $Rainfall_t$). The number of endogenous variables in the supply equation (m) is 2 ($Rubberq_t^S$ and $Rubberp_t$). A mathematical formulation of the order condition is the following:

$$6-4 \quad \geq \quad 2-1$$

$$2 \quad \geq \quad 1$$

From the condition for identification, the number of all variables in the system excluding the variables in the supply equation is greater than the number of endogenous variables in the supply equation subtracted by one. Thus, the supply model is identified.

The test for identification shows that these demand and supply models are identified. Thus, the two-stage least squares method can be performed.

Multicollinearity Test

The multicollinearity test will determine each of the exogenous variables (equation (1) - (4)) in order to avoid the unreliable and unstable estimates of regression coefficients. The results from Table 4.1 show the Variance Inflation Factors (VIFs) between lnUSAGDP, lnUSCarsales, lnRainfall and lnRicep have no multicollinearity problem with VIF's of 1.644, 2.191, 1.599 and 2.506, respectively.

Table 4.1 Results of multicollinearity test

Variables	R-square[19]	VIF
lnUSAGDP	0.392	1.644
lnUSCarsales	0.544	2.191
lnRainfall	0.374	1.599
lnRicep	0.601	2.506

[19] Appendix 7

Instrumental Variables Estimation by Two-Stage Least Squares and Autocorrelation Test

First Stage

The variable that was causing the problem (original endogenous explanatory variable that creates the bias problem), in this study is $lnRubberp_t$. Using the ordinary least squares estimation procedure, $lnRubberp_t$ (equation (11)) was estimated.

Equilibrium price model:

$$lnRubberp_t = \alpha_0 + \alpha_1 lnUSAGDP_t + \alpha_2 lnUSCarsales_t + \alpha_3 lnRicep_t + \alpha_4 lnRainfall_t + Ꞷ_t$$

Table 4.2 Result of Equilibrium price model

Dependent Variable: LNRUBBERP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.[20]
LNRAINFALL***	1.09525	0.230456	4.752541	0.0000
LNRICEP***	0.7672	0.17867	4.293978	0.0002
LNUSAGDP***	0.41791	0.098639	4.236755	0.0002
LNUSCARSALES^{NS}	0.02037	0.373715	0.054508	0.9569
C^{NS}	-10.2747	6.286749	-1.63434	0.1123
R-squared	0.864993		Durbin-Watson stat	1.591063
Adjusted R-squared	0.847572			
*** Significant at 0.01 level ** Significant at 0.05 level * Significant at 0.10 level NS Not Significant				

From the result, for every 1 percent change in the U.S. GDP per capita, U.S. vehicle sales, rainfall and rice price, the price of rubber will change by 0.42, 0.02, 1.10 and 0.77 percent in the same direction, respectively. The coefficient of the U.S.

[20] The p-value is the probability (Prob.) associated with the t-test, which is the smallest level of significance at that the null hypothesis can be rejected (DeFusco et al., 2007).
H_0: $\alpha = 0$; the true parameter is equals to zero
H_1: $\alpha \neq 0$; the true parameter is not equals to zero
Where:
α is the parameter ($\alpha_0, \alpha_1, \alpha_2, \alpha_3, \alpha_4, \beta_0, \beta_1, \beta_2, \beta_3, \gamma_0, \gamma_1, \gamma_2, \gamma_3$) in the regression equations

GDP per capita, rainfall and rice price all have p-values of 0.00, so we reject the null hypothesis that the true parameter is equal to zero at the 0.01 level of significance. Thus the coefficient of the U.S. GDP per capita, rainfall and rice price are significant at the 1 percent level. However, the coefficient of U.S. vehicle sales and the constant have p-values of 0.96 and 0.11, respectively, so we fail to reject the null hypothesis that the true parameter is equal to zero at the 0.10 level of significance. Thus the coefficient of U.S. vehicle sales and the constant have no significant values.

After estimating the equilibrium price model, a new variable was generated (lnEstp) that estimates the price of rubber based on the first stage. The variable lnEstp can be written as the following equation:

$$lnEstp_t = 0.41791*lnUSAGDP_t + 0.02037*lnUSCarsales_t + 1.09525*lnRainfall_t + 0.76720*lnRicep_t - 10.27466$$

Second Stage

Next the structural models were estimated for the explanatory endogenous variable (lnEstp). Using the ordinary least squares estimation procedure, the structural models (Demand equation (12) and Supply equation (13)) was estimated as follows:

Demand model

$$lnRubberq_t^D = \beta_0 + \beta_1 lnEstp_t + \beta_2 lnUSAGDP_t + \beta_3 lnUSCarsales_t + \varepsilon_t$$

Table 4.3 Result of demand model

Dependent Variable: LNRUBBERQ Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNESTP^{NS}	-0.04040	0.065391	-0.61776	0.5411
LNUSAGDP***	1.38501	0.073204	18.91993	0.0000
LNUSCARSALES^{NS}	0.271734	0.176454	1.53997	0.1334
C^{NS}	-4.08249	2.748021	-1.48561	0.1472
R-squared	0.971036		Durbin-Watson stat	0.397131
Adjusted R-squared	0.96832			
*** Significant at 0.01 level ** Significant at 0.05 level * Significant at 0.10 level NS Not Significant				

In the demand model, the results from table 4.3 show all coefficients have the expected sign. The U.S. GDP per capita has the p-value of 0.00, so we reject the null hypothesis that the true parameter is equal to zero at the 0.01 level of significance. Thus, the coefficient of the U.S.GDP per capita is significant at the 1 percent level. The coefficient of estimated price, U.S. vehicles sold and constant have p-values of 0.54, 0.13 and 0.15, respectively, so we fail to reject the null hypothesis that the true parameter is equal to zero at the 0.10 level of significance. Thus, the coefficient of the estimated price, U.S. vehicles sold and constant have no significant values. However, the model has a Durbin-Watson (DW) statistic (test for autocorrelation of the error) of 0.397131. The demand model has 36 (n=36) observations with 3 (k=3) number of regressors excluding the intercept. At a significant level of 5 percent, the test statistic is still outside the regions (1.442 < DW < 2.902) where we reject the null hypothesis H_0 of no autocorrelation. We found that our error term in the model has autocorrelation[21]. Therefore, first order autoregressive is necessary to add into the model to fixed autocorrelation problem.

Demand model with AR(1) autocorrelation

From the result of the Durbin-Watson value in the above test, the current error term ($\mathcal{E}_t$) is correlated with the error in the previous period ($\mathcal{E}_{t-1}$). Thus, the AR(1) variable is added as an additional independent variable in the demand model to transform the original autoregressive error term into one with a non-correlated error term. Thus, the current error term (ζ_t) is now uncorrelated with the error in the previous period (ζ_{t-1}) by the following equation:

$$\ln Rubberq_t^D = \beta_0 + \beta_1 \ln Estp_t + \beta_2 \ln USAGDP_t + \beta_3 \ln USCarsales_t + \mathcal{E}_t$$

Where: $\mathcal{E}_t = \text{Ø}\mathcal{E}_{t-1} + \zeta_t$

Table 4.4 Result of demand model with AR(1)

Dependent Variable: LNRUBBERQ Method: Least Squares Included observations: 35				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNESTP^{NS}	-0.02421	0.051398	-0.47096	0.6411
LNUSAGDP***	1.410768	0.186243	7.574869	0.0000
LNUSCARSALES^{NS}	0.056942	0.146982	0.387406	0.7012
C^{NS}	-0.94797	2.558373	-0.37053	0.7136
AR(1)	0.807359	0.099349	8.126495	0.0000
R-squared	0.989742	Durbin-Watson stat		1.470521
Adjusted R-squared	0.988374			
*** Significant at 0.01 level ** Significant at 0.05 level * Significant at 0.10 level NS Not Significant				

After the AR(1) variable is added to the model, the demand model has a Durbin Watson (DW) statistic of 1.470521. The test statistic is within the regions

[21] Appendix 4: Figure A-1

where we fail to reject H_0: no autocorrelation at 5 percent level of significance[22] where the do not reject region is 1.439 < DW < 2.915.

Natural rubber demand model

The results from table 4.4 show natural rubber demand response which is given as:

$$\ln Rubberq_t^D = -0.947965 - 0.024206 \ln Estp_t + 1.410768 \ln USAGDP_t + 0.056942 \ln USCarsales_t$$

The demand model fits the data well with an R^2 of 0.989742. This means that 98.97 percent of the variation is explained by the explanatory variables: estimated price, the United State of America GDP per capita, and the number of vehicles sold in the United States. The responses of the dependent variable (total rubber quantity) are positive for the U.S. GDP per capita and the U.S. vehicle sold variation, and negative for estimated price variable.

From the result, for every 1 percent change in the U.S. GDP per capita, the quantity of rubber demand will change by 1.4 percent in the same direction. The coefficient of the U.S. GDP per capita has the same expected sign as the studies of Suwanakul and Wailes (1987) and Jaitung (2011) show. The coefficient of the U.S. GDP per capita has a p-value of 0.00, so we reject the null hypothesis that the true parameter is equal to zero at the 0.01 level of significance. Thus, the coefficient of the U.S. GDP per capita is significant at the 1 percent level.

Every 1 percent change of the estimated price caused a change in the quantity of rubber demand in the opposite direction by 0.02 percent; and the coefficient of the estimated price has the expected sign based on the law of demand. Also, every 1 percent change in U.S. vehicles sold caused a change in the quantity of rubber

[22] Appendix 4: Figure A-2

demand in the opposite direction by 0.06 percent as expected. However, the coefficient of estimated price, U.S. vehicles sold and the constant have p-values of 0.64, 0.70 and 0.71, respectively, so we fail to reject the null hypothesis that the true parameter is equal to zero at the 0.10 level of significance. Thus, the coefficient of estimated price, U.S. vehicles sold and the constant have no significant values.

Supply model

$$lnRubberq_t^S = \gamma_0 + \gamma_1 lnEstp_t + \gamma_2 lnRainfall + \gamma_3 lnRicep_t + \mu_t$$

Table 4.5 Result of supply model

Dependent Variable: LNRUBBERQ Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNESTP***	3.353918	0.114559	29.27686	0.0000
LNRAINFALL***	-3.76497	0.211476	-17.8033	0.0000
LNRICEP***	-2.63694	0.114533	-23.0235	0.0000
C***	34.33118	1.274514	26.93668	0.0000
R-squared	0.969853		Durbin-Watson stat	0.372695
Adjusted R-squared	0.967026			
*** Significant at 0.01 level ** Significant at 0.05 level * Significant at 0.10 level NS Not Significant				

In the supply model, the results from table 4.5 show the coefficient of estimated price, rainfall, rice price and constant, which have the expected signs. The coefficient of estimated price, rainfall, rice price and constant all have p-values of 0.00, so we reject the null hypothesis that the true parameter is equal to zero at the 0.01 level of significance. Thus, the coefficient of estimated price, rainfall, rice price and constant are significant at the 1 percent level. However, the model has Durbin-Watson (DW) statistic (test for autocorrelation of the error) of 0.372695. The supply model has 36 (n=36) observations with 3 (k=3) number of regressors excluding the intercept. For a significance level of 5 percent, the test statistic is still outside the regions (1.442 < DW < 2.902) where we reject the null hypothesis H_0: no autocorrelation. We found that our error term in the model has autocorrelation[23]. Therefore, first order autoregressive is necessary to add into the model to fixed autocorrelation problems.

Supply model with AR(1) autocorrelation

The same as the demand model from the result of the Durbin-Watson value above, the current error term (μ_t) is correlated with the error in the previous period (μ_{t-1}). Thus, the AR(1) variable is added as an additional independent variable in the supply model to transform the original autoregressive error term into one with a non-correlated error term. Thus, the current error term (ε_t) is now uncorrelated with the error in the previous period (ε_{t-1}) by the following equation:

$$lnRubberq_t^S = \gamma_0 + \gamma_1 lnEstp_t + \gamma_2 lnRainfall_t + \gamma_3 lnRicep_t + \mu_t$$

Where: $\mu_t = \phi\mu_{t-1} + \varepsilon_t$

[23] Appendix 4: Figure A-3

Table 4.6 Result of supply model with AR(1)

Dependent Variable: LNRUBBERQ Method: Least Squares Included observations: 35				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNESTP***	3.318948	0.4279	7.756369	0.0000
LNRAINFALL***	-3.60015	0.483565	-7.445	0.0000
LNRICEP***	-2.62997	0.34392	-7.64705	0.0000
C***	33.27677	2.587637	12.85991	0.0000
AR(1)	0.824389	0.098261	8.389808	0.0000
R-squared	0.990352	Durbin-Watson stat		1.454453
Adjusted R-squared	0.989066			
*** Significant at 0.01 level ** Significant at 0.05 level * Significant at 0.10 level NS Not Significant				

After we put the AR(1) variable into the supply model, the model has a Durbin Watson (DW) statistic of 1.454453. The test statistic is within the regions where we fail to reject H_0: no autocorrelation at 5 percent level of significance[24] where the do not reject region is 1.439 < DW < 2.915.

Natural rubber supply model

The results from table 4.6 show natural rubber supply response which is given as:

$$\ln Rubberq_t^S = 33.27677 + 3.318948 \ln Estp_t - 3.600145 \ln Rainfall_t - 2.629971 \ln Ricep_t$$

The supply model fits the data well with an R^2 of 0.990352; it explains 99 percent of the model variation by the explanatory variables: estimated price, rainfall and rice price. The responses of the dependent variable (total rubber quantity) are

[24] Appendix 4: Figure A-4

positive for the estimated price explanatory variable, negative for rainfall and rice price explanatory variables.

From the result, for every 1 percent change in the estimated price, the quantity of rubber production will change by 3.3 percent in the same direction; the coefficient of estimated price has the expected sign as in the law of supply. For every 1 percent change of the rainfall, the quantity of rubber production will change by 3.6 percent in the opposite direction; the coefficient of rainfall has the expected sign as shown in the study of Mesike and Esekhade (2014). For every 1 percent change in the rice price, the quantity of rubber production will change 2.62 percent in the opposite direction; the coefficient of rice price has the expected sign as shown in the studies of Much, Tongpan and Sirisupluxana (2011) and Molua (2010). The coefficient of estimated price, rainfall, rice price and constant all have p-values of 0.00, so we reject the null hypothesis that the true parameter is equal to zero at the 0.01 level of significance. Thus, the coefficient of estimated price, rainfall, rice price and constant are significant at the1 percent level.

Endogeneity Test

The Durbin-Wu-Hausman Test will be used to check for the existence of endogeneity in the demand and supply model.

Test for Endogeneity problem in Demand model

First, check for the existence of endogeneity in the demand model by adding RESID01 as the additional explanatory variable in the model as shown by the following equation:

$$lnRubberq_t^D = \beta_0 + \beta_1 lnEstp_t + \beta_2 lnUSAGDP_t + \beta_3 lnUSCarsales_t + \beta_4 RESID01_t + \varepsilon_t$$

Table 4.7 Result of endogeneity test in demand model

Dependent Variable: LNRUBBERQ Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNESTP^{NS}	-0.0404	0.065849	-0.61347	0.5440
LNUSAGDP***	1.38501	0.073716	18.78838	0.0000
LNUSCARSALES^{NS}	0.271734	0.17769	1.529263	0.1363
RESID01^{NS}	-0.07409	0.099313	-0.74603	0.4613
C^{NS}	-4.08249	2.767262	-1.47528	0.1502
*** Significant at 0.01 level ** Significant at 0.05 level * Significant at 0.10 level NS Not Significant				

Table 4.7 presents the endogeneity test result. The coefficient of RESID01 has p-value of 0.4613, so we fail to reject the null hypothesis that the true parameter is equal to zero at the 0.10 level of significance. Thus, the coefficient of RESID01 is not significant. It can be concluded that the demand model has no endogeneity problem.

Test for Endogeneity problem in Supply model

Secondly, check for the existence of endogeneity in the supply model by adding RESID01 as the additional explanatory variable in the model as shown by the following equation:

$$\ln Rubberq_t^S = \gamma_0 + \gamma_1 \ln Estp_t + \gamma_2 \ln Rainfall + \gamma_3 \ln Ricep_t + \gamma_4 RESID01_t + \mu_t$$

Table 4.8 Result of endogeneity test in supply model

Dependent Variable: LNRUBBERQ Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNESTP***	3.353918	0.115401	29.06306	0.0000
LNRAINFALL***	-3.76497	0.213031	-17.6733	0.0000
LNRICEP***	-2.63694	0.115375	-22.8554	0.0000
RESID01^{NS}	-0.07409	0.101357	-0.73098	0.4703
C***	34.33118	1.28389	26.73997	0.0000
*** Significant at 0.01 level ** Significant at 0.05 level * Significant at 0.10 level NS Not Significant				

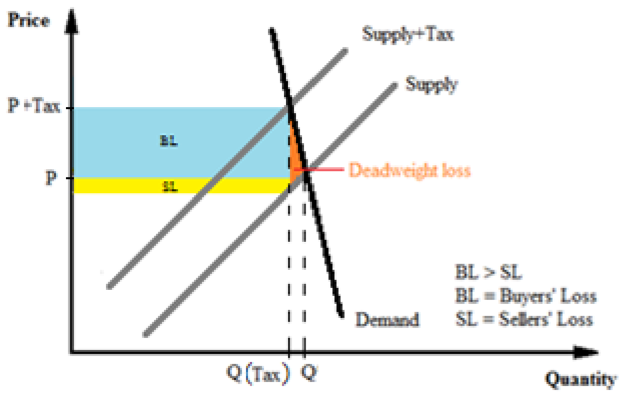
Table 4.8 presents the endogeneity test result. The coefficient of RESID01 has p-value of 0.4703, so we fail to reject the null hypothesis that the true parameter is equal to zero at the 0.10 level of significance. Thus, the coefficient of RESID01 is no significant values. It can be concluded that the supply model has no endogeneity problem.

Tax incidence and deadweight loss of rubber market in Thailand

Tax incidence is when an actual taxpayer must finally bear the monetary burden of taxation. Tax incidence does not depend on where the revenue is collected; it depends on the relative elasticities of demand and supply with the less elastic side bearing more tax burden (Cox, Rider and Sen as cited in Oner, 2013).

The imposing a tax will reduce the quantity and create a deadweight loss that depends on the elasticity of demand. Deadweight loss of a tax is the loss in buyer’s surplus and seller’s surplus (Goolsbee, 2006).

Figure 4.1 Price elasticity of demand and supply model



Based on the results of this study the tax incidence of buyers and sellers can calculate by using the following formulas:

Tax incidence of buyers:

PED/(PED+PES)*100%

0.02/(0.02+3.31)*100% = 0.6%

Tax incidence of sellers:

PED/(PED+PES)*100%

3.31/(0.02+3.31)*100% = 99.4%

Where:

PED is the price elasticity of demand

PES is the price elasticity of supply

The results show tax incidence falling on buyers by 99.4% and falling on sellers by 0.6%. Therefore, it can be concluded that buyers bear almost entirely the tax burden in the rubber market in Thailand. In this study, rubber price is inelastic (0.02) to rubber demand, which means when taxed, the quantity will have little change (Q and Q after tax are close). The deadweight loss is smaller for the seller than the buyer. Figure 4.1 above demonstrates a scenario when demand is highly inelastic and supply is more elastic.

Chapter 5

CONCLUSIONS

Summary

This study has presented the demand and supply model of natural rubber in Thailand and determines a relationship between the demand and supply of rubber with its determinants. The data contained in the study is secondary annual time series data from 1977-2012. Data was procured from the Thailand Office of Agricultural Economics (OAE), Bank of Thailand, Ward's Automotive Group (WardsAuto), Food and Agriculture Organization of the United Nations (FAO) and World Bank.

The results conducted by using the Eviews 8 econometric software herein consist of four parts by following the procedures for data analysis in chapter 3. First, the results from the condition for identification showed that the demand and supply models are identified. Secondly, the results from the multicollinearity test showed the Variance Inflation Factors (VIFs) between USAGDP, USCarsales, Rainfall and Ricep. They have no multicollinarity problem with 1.644, 2.191, 1.599 and 2.506, respectively. Thirdly, after correcting for an autocorrelation problem in the regression, the results of the instrumental variables estimation by two-stage least squares method provided the following results: the rubber demand has a positive relationship with the U.S. GDP per capita. Every 1 percent change in the U.S. GDP per capita will cause the quantity of rubber demanded to change by 1.4 percent in the same direction. The rubber supply has a positive relationship with estimated price and a negative relationship with rainfall and rice price (alternative crop). With every 1 percent change in the estimated price, the quantity of rubber production will change by 3.3

percent in the same direction. An increasing in rubber price will encourage farmers to produce more rubber to the market. However, the quantity of rubber production will change by 3.6 percent and 2.62 percent in the opposite direction, for every 1 percent change of the rainfall and rice price, respectively. Lastly, the results from the endogeneity test showed that the additional explanatory variable RESID01 in demand and supply model in this study have no significant value with p-values of 0.4613 and 0.4703, respectively. Thus, it can be concluded that the demand and supply model in this study have no endogeneity problem.

Conclusions

The results of the study provide evidence that rubber farmers in Thailand respond to economic incentives and environmental factors in the production. The rubber demand model yielded a significant and positive relationship only with the U.S. GDP per capita. The rubber supply model yielded a significant and positive relationship with its own price; however, it also yielded a significant but negative relationship with rainfall and price of an alternative crop.

From the results of the demand model in this study, the rubber demand is almost perfectly inelastic to price, which means the demand for rubber is almost unaffected when the price of rubber changes. No matter how much the rubber cost consumers are willing to pay for it because the rubber has almost no substitute products.

The U.S.GDP per capita affect the quantity of rubber demand in Thailand as expected. Thailand exports natural rubber to the U.S., which is the 3rd largest importer of Thai rubber. Due to the fact that the U.S. is the 2nd largest vehicle selling country in the world and rubber products are mainly used in the automotive industry, when the

U.S. GDP per capita is increased, the growth in the U.S. economy is increased as well. This can benefit the automotive productions and sales in the U.S., which can resulted in their rubber demand increasing. The results of a relationship between quantity of rubber demand and the U.S. GDP per capita in this study are in line with previous studies which showed that the U.S. GDP has a positive relationship with the quantity of rubber demand. Some examples are the study of Jaitung (2011) where he found that the U.S. GDP had a positive relationship with the rubber demand in Thailand similar to Suwanakul and Wailes (1987) found that the U.S. GDP had a positive relationship with U.S. rubber consumption. These results in this study will be a benefit to rubber farmers in planning their output production to meet the needs of the market by looking at the trends in the U.S. GDP per capita.

Due to the fact that rubber supply is elastic to price, there is evidence that Thailand has plenty of spare production capacity for rubber. It has a large amount of rubber trees, but a shortage in labor. This means Thailand has more potential to increase production from yielding rubber trees. Nevertheless, this is not the case when prices fall because most of rubber plantations are owned by smallholders. These producers cannot reduce the production because they receive their sole income from rubber. Therefore, the government should have a policy to control the production of rubber.

Secondly, producers can increase output without substantial time delay. Unlike the other seasonal crops, rubber has a short time span, from yielding rubber products that reach the marketplace. This time span is usually between a day or two. Therefore, the rubber production can respond quickly to the price. Moreover, products from rubber can also be stored for longer periods of time and sold when it has a better price, unlike other agricultural products that are more perishable. The results of a relationship between rubber price and quantity of rubber supply in this study are in accordance with the law of supply, which states that as the price of goods increase the quantity supplied increases as well. In other words, it has a positive relationship between the quantity of supply and price (Moffatt, n.d.).

The impact of changes in the price of an alternative crop like paddy rice is significant, but has a negative relationship with rubber supply, because when the price of the alternative crop decreases, the rubber quantity increases. This may be an indication of farmers switching to an alternative crop. During 2001-2011, the price of rubber increased steadily. Hoping to better their income, many rice farmers turned to growing rubber. This phenomenon is called the rubber boom, and from the results of this study, we assume that although the rice price fell only slightly, farmers had enough incentive to turn to growing rubber and did so in larger numbers. The results of a relationship between quantity of rubber supply and alternative crop in this study are in line with previous studies which showed that the alternative crop has a negative relationship with the quantity of main crop such as the study of Much, Tongpan and Sirisupluxana (2013) where they found that the cassava price had a negative relationship with the yield of rubber in Cambodia. And just as Mushtaq and Dawson (2003) found that the wheat supply had a negative relationship with the prices of cotton in Pakistan.

Rainfall is the dominant controlling variable in rubber plantation because it supplies soil moisture and soil nutrients. Thus, it will facilitate the growing of rubber. High rainfall for a long period can also have a negative impact on rubber. Rainfall gave a significant and negative relationship, which directly affects the rubber production by washing latex away. Consequently, farmers will not harvest rubber when there are heavy rains, so rubber production is normally low during the rainy season. The results of a relationship between quantity of rubber supply and rainfall in this study are in line with the results of a previous study done by Mesike and Esekhade (2014), which found that a negative relationship exists between the total quantity of rubber supply and rainfall in Nigeria. They gave a recommendation that farmers should use protective waterproof containers for collection of latex during the raining season to prevent the washing away of latex by rain.

This study found some significant results for tax incidence that the price elasticity of demand is less elastic than supply. This causes the tax incidence to fall more on buyers (99.4%) than on sellers (0.6%). Therefore, it can be concluded that buyers bear almost entirely the tax burden in the rubber market in Thailand. In terms of deadweight loss of a tax, the rubber quantity is inelastic for rubber demand, which means when taxed, the quantity will have little change. The deadweight loss is greater for the buyers of rubber than the sellers.

The practical usefulness of elasticity of demand and supply is to formulate government policies in designing public finance policies. Based on the results of this study, a tax that is put on consumers or producers of rubber will fall almost entirely on consumers. With this tax, the elasticities of supply and demand will cause the equilibrium quantity to reduce by a relatively small amount. Given this new tax revenue, the government can ensure that producers are not detrimentally affected by the tax if it provides a decoupled payment to the producers. The decoupled payments are the government's support that would not have any effect on current conditions associated with production or production factors, nor create any influence on a farmer's production decision (OECD, 2005). These payments can help guard against the threat of income insecurity that will benefit farmers in Thailand.

Nowadays, it seems that the rubber production in Thailand might not grow as quickly as in the past due to the rubber price falling. Thus, the government should support research and development into rubber cultivation and harvesting and introduce this knowledge to farmers to improve output efficiency and the quality of rubber products. Also, the government should increase downstream productions to increase the domestic rubber consumption, which helps prevent an oversupply of rubber products. Also, the government should increase downstream productions to increase the domestic rubber consumption, which helps prevent an oversupply of natural rubber products and adds value to natural rubber products. Furthermore, they must encourage farmers to plant modern high yielding varieties to reduce production costs and implement better practice; this will increase their ability to compete with the other major rubber producing countries.

Recommendations

The results of this study should be viewed as an estimation of effects of rubber demand and supply response in Thailand, which should be useful for government policy makers to determine rubber production policies. As a recommendation, further analysis can be developed in three areas.

First, because of its limited time and data, we could only develop the model from data that is currently available. If further studies have more data available for their use they should test the model again or perhaps use a different methodology to compare the results. Also during the procedure for data collection, we compared data from multiple data sources to avoid data errors and to find the most accurate data. With the addition of more reliable data, future studies could estimate more accurate results.

Secondly, the researcher suggests different responses may be found in each region or province, so other models used for estimation should be based on specific rubber growing locations. There can be a number of other crops that could have an effect on rubber production in different regions or locations. The study will be more meaningful it could focus more specifically on the crop region.

In addition, the agricultural sector in Thailand has gone through a variety of policies, which has affected the product market such as establishing 160,000 hectares of new rubber acreage and insuring a standard price of rubber. Therefore, policies should be considered as an important variable. Therefore, further studies should use policy variables as an important factor.

Finally, the approach developed in this study could be used for analysis of the demand and supply response in agriculture to benefit researchers and producers in Thailand and around the world.

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APPENDIX 1: Complete Data Set of Supply Response of Natural Rubber Production in Thailand, 1977-2012.

Year	Quantity of Rubber production (MT)	rubber price (US$/MT)	Rice price (US$/MT)	Average Rainfall (mm)	U.S. Vehicle Sales	U.S. GDP per capita (current US$)	China GDP per capita (current US$)	Japan GDP per capita (current US$)	Exchange Rate (Baht/US$)
1977	430,900	487.75	252.45	1,841.04	14,859,000	9,471.53	182.68	6,230.34	20.40
1978	467,000	619.96	345.62	1,426.56	15,423,000	10,587.42	154.97	8,675.01	20.34
1979	534,300	703.23	312.93	1,503.00	14,153,000	11,695.36	182.28	8,953.59	20.42
1980	465,200	814.89	410.5	1,711.20	11,443,613	12,597.65	193.02	9,307.84	19.61
1981	507,700	645.68	458.76	1,344.00	10,777,980	13,992.92	195.31	10,212.38	20.49
1982	576,000	568.95	272.51	1,678.92	10,538,362	14,439.02	201.44	9,428.87	21.32
1983	593,900	678.01	256.76	1,452.84	12,311,516	15,561.27	223.25	10,213.96	21.46
1984	617,200	649.08	232.35	1,360.80	14,483,141	17,134.32	248.29	10,786.79	22.94
1985	773,000	548.74	196.8	1,477.80	15,725,291	18,269.28	291.77	11,465.73	26.88
1986	956,000	597.4	186.4	1,533.12	16,323,021	19,114.82	279.19	16,882.27	26.18
1987	1,067,000	716.84	214.7	1,514.64	15,192,946	20,100.79	249.41	20,355.61	25.71
1988	1,159,000	853.87	277.65	2,190.12	15,791,544	21,483.11	280.97	24,592.77	25.32
1989	1,311,000	684.87	299.14	1,505.88	14,845,261	22,922.47	307.49	24,505.77	25.64
1990	1,418,000	673.07	270.87	1,428.84	14,149,378	23,954.52	314.43	25,123.63	25.51
1991	1,505,000	636.72	293.14	1,398.36	12,549,523	24,404.99	329.75	28,540.77	25.38
1992	1,712,000	663.9	268.17	1,059.72	13,117,444	25,492.96	362.81	31,013.65	25.32
1993	1,811,000	633.98	235.41	1,571.64	14,198,854	26,464.78	373.80	35,451.30	25.19
1994	1,988,000	913.81	267.76	1,764.36	15,411,374	27,776.43	469.21	38,814.89	25.06
1995	2,061,000	1,253.62	321.14	1,666.92	15,116,325	28,781.95	604.23	42,522.07	24.88

1996	2,120,944	1,083.73	338.86	1,405.68	15,456,112	30,068.23	703.12	37,421.67	25.32
1997	2,168,720	777.89	303.43	1,411.92	15,497,860	31,572.64	774.47	34,294.90	29.76
1998	2,162,411	556.83	304.26	1,603.80	15,967,287	32,948.95	820.86	30,967.29	40.82
1999	2,198,540	480.13	248.54	1,155.96	17,414,728	34,639.12	864.73	34,998.81	37.74
2000	2,278,653	538.25	202.5	1,407.96	17,811,673	36,467.30	949.18	37,291.71	40.00
2001	2,522,508	461.75	172.82	1,385.88	17,472,378	37,285.82	1,041.64	32,716.42	44.44
2002	2,633,124	645.15	191.99	1,632.12	17,138,652	38,175.38	1,135.45	31,235.59	42.92
2003	2,860,093	910.1	197.64	2,068.08	16,967,442	39,682.47	1,273.64	33,690.94	41.49
2004	3,006,720	1,098.86	237.55	1,726.08	17,298,573	41,928.89	1,490.38	36,441.50	40.16
2005	2,979,722	1,333.91	286.35	1,821.12	17,444,329	44,313.59	1,731.13	35,781.23	40.16
2006	3,070,520	1,748.68	304.91	2,365.32	17,048,981	46,443.81	2,069.34	34,102.21	37.88
2007	3,024,207	2,143.08	326.28	1,840.44	16,460,315	48,070.38	2,651.26	34,094.89	32.15
2008	3,166,910	2,224.71	650.26	2,169.12	13,493,165	48,407.08	3,413.59	37,972.24	33.11
2009	3,090,280	1,703.18	554.91	1,992.72	10,601,368	46,998.82	3,749.27	39,473.36	34.33
2010	3,051,781	3,247.16	488.97	2,187.84	11,772,219	48,357.68	4,433.36	43,117.77	31.72
2011	3,348,897	4,068.24	542.98	2,718.12	13,040,613	49,853.68	5,447.34	46,134.57	30.48
2012	3,500,000	2,888.96	562.92	2,384.40	14,785,936	51,748.56	6,091.01	46,720.36	31.07

Year	Palm Oil price (US$/MT)	World GDP per capita (current US$)	World Passenger Cars Production
1977	529.9	1,717.30	30,500,000
1978	600.29	1,989.30	31,200,000
1979	653.77	2,265.90	30,800,000
1980	583.89	2,502.70	28,600,000
1981	570.52	2,530.50	27,500,000
1982	445.12	2,463.50	26,700,000
1983	501.4	2,475.70	30,000,000
1984	728.86	2,526.10	30,500,000
1985	500.74	2,611.00	32,400,000
1986	257.07	3,033.00	32,900,000
1987	342.67	3,381.90	33,100,000
1988	437.2	3,718.00	34,400,000
1989	350.23	3,838.40	35,700,000
1990	289.69	4,214.20	36,300,000
1991	338.85	4,350.20	35,100,000
1992	393.36	4,583.40	35,500,000
1993	377.93	4,597.40	34,200,000
1994	528.33	4,864.40	35,400,000
1995	628.22	5,303.60	36,100,000
1996	530.81	5,339.20	37,400,000
1997	545.7	5,254.60	39,400,000

1998	670.99	5,163.30	38,600,000
1999	435.88	5,285.80	40,100,000
2000	310.25	5,387.40	41,300,000
2001	285.78	5,289.10	40,100,000
2002	390.26	5,422.60	41,500,000
2003	443.24	6,009.00	42,200,000
2004	471.36	6,680.00	44,400,000
2005	422.06	7,140.00	45,900,000
2006	478.35	7,639.40	49,100,000
2007	780.4	8,500.70	52,100,000
2008	948.66	9,212.10	51,300,000
2009	682.78	8,626.30	45,300,000
2010	900.69	9,306.10	60,100,000
2011	1,125.33	10,195.80	62,627,000
2012	999.36	10,291.10	66,723,000

APPENDIX 2: Strategy to derive the reduced form equation for $Rubberp_t$

Equilibrium price model can be obtained by:

$$lnRubberq_t^D = \beta_0 + \beta_1 lnRubberp_t + \beta_2 lnUSAGDP_t + \beta_3 lnUSCarsales_t + \varepsilon_t \quad \text{(A-1)}$$

$$lnRubberq_t^S = \gamma_0 + \gamma_1 lnRubberp_t + \gamma_2 lnRicep_t + \gamma_3 lnRainfall_t + \mu_t \quad \text{(A-2)}$$

$$lnRubberq_t^S = lnRubberq_t^D = lnRubberq_t \quad \text{(A-3)}$$

From $lnRubberq_t^S = lnRubberq_t^D = lnRubberq_t$ the equations can be written as:

$$lnRubberq_t = \beta_0 + \beta_1 lnRubberp_t + \beta_2 lnUSAGDP_t + \beta_3 lnUSCarsales_t + \varepsilon_t \quad \text{(A-4)}$$

$$lnRubberq_t = \gamma_0 + \gamma_1 lnRubberp_t + \gamma_2 lnRicep_t + \gamma_3 lnRainfall_t + \mu_t \quad \text{(A-5)}$$

Conducting the equation (A-4) - equation (A-5):

$$0 = (\beta_0-\gamma_0) + (\beta_1-\gamma_1)lnRubberp_t + \beta_2 lnUSAGDP_t - \gamma_2 lnRicep_t + \beta_3 lnUSCarsales_t - \gamma_3 lnRainfall_t + (\varepsilon_t-\mu_t) \quad \text{(A-6)}$$

Move $lnRubberp_t$ with coefficient to the left side of the equation:

$$(\gamma_1-\beta_1)lnRubberp_t = (\beta_0-\gamma_0) + \beta_2 lnUSAGDP_t - \gamma_2 lnRicep_t + \beta_3 lnUSCarsales_t - \gamma_3 lnRainfall_t + (\varepsilon_t-\mu_t) \quad \text{(A-7)}$$

Dividing the equation by $(\gamma_1\text{-}\beta_1)$:

$$\ln Rubberp_t \quad = \quad (\beta_0\text{-}\gamma_0)/(\gamma_1\text{-}\beta_1) + \beta_2/(\gamma_1\text{-}\beta_1)\ln USAGDP_t - \gamma_2/(\gamma_1\text{-}\beta_1)\ln Ricep_t + \beta_3/(\gamma_1\text{-}\beta_1)\ln USCarsales_t$$
$$- \gamma_3/(\gamma_1\text{-}\beta_1)\ln Rainfall_t + (\varepsilon_t\text{-}\mu_t)/(\gamma_1\text{-}\beta_1) \qquad \text{(A-8)}$$

Where the following equations specify the 5 α's and Ꙍ:

$\alpha_0 = (\beta_0\text{-}\gamma_0)/(\gamma_1\text{-}\beta_1)$ $\quad$ $\alpha_1 = \beta_2/(\gamma_1\text{-}\beta_1)$ $\quad$ $\alpha_2 = \beta_3/(\gamma_1\text{-}\beta_1)$

$\alpha_3 = -\ \gamma_2/(\gamma_1\text{-}\beta_1)$ $\quad$ $\alpha_4 = -\ \gamma_3/(\gamma_1\text{-}\beta_1)$ $\quad$ $Ꙍ_t = (\varepsilon_t\text{-}\mu_t)/(\gamma_1\text{-}\beta_1)$

Let the α's and Ꙍ represent the constants and coefficients of the reduced form equations:

$$\ln Rubberp_t \quad = \quad \alpha_0 + \alpha_1\ln USAGDP_t + \alpha_2\ln USCarsales_t + \alpha_3\ln Ricep_t + \alpha_4\ln Rainfall_t + Ꙍ_t \qquad \text{(A-9)}$$

Equation (A-3) is equation (10) in chapter 3 and equation (A-9) is equation (11) in chapter 3

APPENDIX 3: Variables used in this study, in order to find the best model.

Table A-1 Pearson's Correlation Test of lnWGDP, lnChinaGDP, lnJapanGDP and lnUSAGDP

	lnWGDP	lnChinaGDP	lnJapanGDP	lnUSAGDP
lnWGDP	1.000	0.949	0.922	0.979
lnChinaGDP	**0.949**	1.000	0.780	0.927
lnJapanGDP	**0.922**	0.780	1.000	0.927
lnUSAGDP	**0.979**	0.927	0.927	1.000

The results from table A-1 found that lnWGDP, lnChinaGDP, lnJapanGDP and lnUSAGDP cannot use in the same model, due to multicollinearity problem

Table A-2 Conclusion of difference exogenous variables in the simultaneous equation models.

Model	Demand model	Supply model
1	$lnRubberq_t^D = lnRubberp_t + lnWGDP_t + lnWCAR_t + \varepsilon_t$	$lnRubberq_t^S = lnRubberp_t + lnRainfall_t + lnRicep_t + \mu_t$
Notation	lnWGDP and lnWCAR have multicollinearity problem	
2	$lnRubberq_t^D = lnRubberp_t + lnChinaGDP_t + lnWCAR_t + \varepsilon_t$	$lnRubberq_t^S = lnRubberp_t + lnRainfall_t + lnRicep_t + \mu_t$
Notation	lnChinaGDP and lnWCAR have multicollinearity problem	
3	$lnRubberq_t^D = lnRubberp_t + lnJapanGDP_t + lnWCAR_t + \varepsilon_t$	$lnRubberq_t^S = lnRubberp_t + lnRainfall_t + lnRicep_t + \mu_t$
Notation	All independent variables have no significant value	

4	$lnRubberq_t^D = lnRubberp_t + lnUSAGDP_t + lnWCAR_t + \varepsilon_t$	$lnRubberq_t^S = lnRubberp_t + lnRainfall_t + lnRicep_t + \mu_t$
Notation	lnUSAGDP and lnWCAR have multicollinearity problem	
5	$lnRubberq_t^D = lnRubberp_t + lnWGDP_t + lnUSCarsales_t + \varepsilon_t$	$lnRubberq_t^S = lnRubberp_t + lnRainfall_t + lnRicep_t + \mu_t$
Notation	All independent variables have no significant value	
6	$lnRubberq_t^D = lnRubberp_t + lnChinaGDP_t + lnUSCarsales_t + \varepsilon_t$	$lnRubberq_t^S = lnRubberp_t + lnRainfall_t + lnRicep_t + \mu_t$
Notation	All independent variables have no significant value	
7	$lnRubberq_t^D = lnRubberp_t + lnJapanGDP_t + lnUSCarsales_t + \varepsilon_t$	$lnRubberq_t^S = lnRubberp_t + lnRainfall_t + lnRicep_t + \mu_t$
Notation	Wrong sign of lnEstp in demand model	
8	$lnRubberq_t^D = lnRubberp_t + lnUSAGDP_t + lnUSCarsales_t + \varepsilon_t$	$lnRubberq_t^S = lnRubberp_t + lnRainfall_t + lnRicep_t + \mu_t$
Notation	The Best Model, which used in the study	
9	$lnRubberq_t^D = lnRubberp_t + lnWGDP_t + lnWCAR_t + \varepsilon_t$	$lnRubberq_t^S = lnRubberp_t + lnRainfall_t + lnPalmoilp_t + \mu_t$
Notation	lnWGDP and lnWCAR have multicollinearity problem	
10	$lnRubberq_t^D = lnRubberp_t + lnChinaGDP_t + lnWCAR_t + \varepsilon_t$	$lnRubberq_t^S = lnRubberp_t + lnRainfall_t + lnPalmoilp_t + \mu_t$
Notation	lnChinaGDP and lnWCAR have multicollinearity problem	
11	$lnRubberq_t^D = lnRubberp_t + lnUSAGDP_t + lnWCAR_t + \varepsilon_t$	$lnRubberq_t^S = lnRubberp_t + lnRainfall_t + lnPalmoilp_t + \mu_t$
Notation	lnUSAGDP and lnWCAR have multicollinearity problem	
12	$lnRubberq_t^D = lnRubberp_t + lnJapanGDP_t + lnWCAR_t + \varepsilon_t$	$lnRubberq_t^S = lnRubberp_t + lnRainfall_t + lnPalmoilp_t + \mu_t$
Notation	lnWCAR have multicollinearity problem	
13	$lnRubberq_t^D = lnRubberp_t + lnWGDP_t + lnUSCarsales_t + \varepsilon_t$	$lnRubberq_t^S = lnRubberp_t + lnRainfall_t + lnPalmoilp_t + \mu_t$
Notation	All independent variables have no significant value	
14	$lnRubberq_t^D = lnRubberp_t + lnChinaGDP_t + lnUSCarsales_t + \varepsilon_t$	$lnRubberq_t^S = lnRubberp_t + lnRainfall_t + lnPalmoilp_t + \mu_t$
Notation	All independent variables have no significant value	

15	$lnRubberq_t^D = lnRubberp_t + lnJapanGDP_t + lnUSCarsales_t + \varepsilon_t$	$lnRubberq_t^S = lnRubberp_t + lnRainfall_t + lnPalmoilp_t + \mu_t$
Notation	Wrong sign of lnEstp in demand model	
16	$lnRubberq_t^D = lnRubberp_t + lnUSAGDP_t + lnUSCarsales_t + \varepsilon_t$	$lnRubberq_t^S = lnRubberp_t + lnRainfall_t + lnPalmoilp_t + \mu_t$
Notation	lnPalmoilp is no significant value	
17	$lnRubberq_t^D = lnRubberp_t + lnWGDP_t + lnUSCarsales_t + lnWCAR_t + \varepsilon_t$	$lnRubberq_t^S = lnRubberp_t + lnRainfall_t + lnRicep_t + lnPalmoilp_t + \mu_t$
Notation	lnWGDP and lnWCAR have multicollinearity problem	
18	$lnRubberq_t^D = lnRubberp_t + lnChinaGDP_t + lnUSCarsales_t + lnWCAR_t + \varepsilon_t$	$lnRubberq_t^S = lnRubberp_t + lnRainfall_t + lnRicep_t + lnPalmoilp_t + \mu_t$
Notation	lnChinaGDP, lnWCAR and lnRicep have multicollinearity problem	
19	$lnRubberq_t^D = lnRubberp_t + lnJapanGDP_t + lnUSCarsales_t + lnWCAR_t + \varepsilon_t$	$lnRubberq_t^S = lnRubberp_t + lnRainfall_t + lnRicep_t + lnPalmoilp_t + \mu_t$
Notation	lnRicep and lnWCAR have multicollinearity problem	
20	$lnRubberq_t^D = lnRubberp_t + lnUSAGDP_t + lnUSCarsales_t + lnWCAR_t + \varepsilon_t$	$lnRubberq_t^S = lnRubberp_t + lnRainfall_t + lnRicep_t + lnPalmoilp_t + \mu_t$
Notation	lnUSAGDP and lnWCAR have multicollinearity problem	

The variables excluding from table 3.1 follow:

lnPalmoilp is natural logarithm of palm oil price. This data was procured from World Bank.

lnWGDP is natural logarithm of the world GDP per capita. This data was procured from World Bank.

lnWCAR is natural logarithm of the world passenger cars production. This data was procured from Worldwatch Institute

Table A-3 Results of multicollinearity test of simultaneous equation model No.1

Variables	R-squared	VIF
LNWGDP	0.865	**7.407**
LNWCAR	0.889	**9.032**
LNRAINFALL	0.481	1.925
LNRICEP	0.276	1.381

The simultaneous equation model No.1 has multicollinearity problem in the variables lnWGDP and lnWCAR with VIFs 7.407 and 9.032, respectively. However, lnRainfall and lnRicep have no multicollinearity problem with VIFs 1.925 and 1.381, respectively.

Table A-4 Results of regression between lnWGDP with lnWCAR, lnRainfall and lnRicep

Dependent Variable: LNWGDP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNWCAR	2.148793	0.184457	11.64926	0.0000
LNRAINFALL	-0.250725	0.208417	-1.202996	0.2378
LNRICEP	0.02157	0.111652	0.193186	0.8480
C	-27.36099	2.552277	-10.72023	0.0000
R-squared	0.866552			
Adjusted R-squared	0.854042			

Table A-5 Results of regression between lnWCAR with lnWGDP, lnRainfall and lnRicep

Dependent Variable: LNWCAR Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNWGDP	0.376578	0.032326	11.64926	0.0000
LNRAINFALL	0.208235	0.081251	2.562868	0.0153
LNRICEP	0.013927	0.046703	0.298194	0.7675
C	12.66652	0.477225	26.54206	0.0000
R-squared	0.889282			
Adjusted R-squared	0.878902			

Table A-6 Results of regression between lnRainfall with lnWGDP, lnWCAR, and lnRicep

Dependent Variable: LNRAINFALL Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNWCAR	0.817838	0.319111	2.562868	0.0153
LNWGDP	-0.172572	0.143452	-1.202996	0.2378
LNRICEP	0.164578	0.088	1.870199	0.0706
C	-6.353888	4.395939	-1.4454	0.1581
R-squared	0.480608			
Adjusted R-squared	0.431915			

Table A-7 Results of regression between lnRicep with lnWGDP, lnWCAR, and lnRainfall

Dependent Variable: LNRICEP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNRAINFALL	0.598695	0.320124	1.870199	0.0706
LNWCAR	0.198973	0.667262	0.298194	0.7675
LNWGDP	0.054007	0.279561	0.193186	0.848
C	-2.675396	8.64078	-0.309624	0.7589
R-squared	0.275630			
Adjusted R-squared	0.207721			

Table A-8 Results of multicollinearity test of simultaneous equation model No.2

Variables	R-squared	VIF
LNCHINAGDP	0.930	**14.315**
LNWCAR	0.930	**14.293**
LNRAINFALL	0.458	1.846
LNRICEP	0.285	1.398

The simultaneous equation model No.2 has a multicollinearity problem in the variables lnChinaGDP and lnWCAR with VIFs 14.315 and 14.293, respectively. However, lnRainfall and lnRicep have no multicollinearity problem with VIFs 1.846 and 1.398, respectively.

Table A-9 Results of regression between lnChinaGDP with lnWCAR, lnRainfall and lnRicep

Dependent Variable: LNCHINAGDP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNWCAR	4.525503	0.296226	15.27721	0.0000
LNRAINFALL	0.08596	0.334703	0.256825	0.7990
LNRICEP	0.12068	0.179306	0.673043	0.5058
C	-73.85834	4.098778	-18.0196	0.0000
R-squared	0.930144			
Adjusted R-squared	0.923595			

Table A-10 Results of regression between lnWCAR with lnChinaGDP, lnRainfall and lnRicep

Dependent Variable: LNWCAR Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNCHINAGDP	0.194326	0.01272	15.27721	0.0000
LNRAINFALL	0.055219	0.068739	0.803306	0.4277
LNRICEP	-0.009518	0.03738	-0.254631	0.8006
C	15.8458	0.441469	35.89336	0.0000
R-squared	0.930036			
Adjusted R-squared	0.923477			

Table A-11 Results of regression between lnRainfall with lnChinaGDP, lnWCAR, and lnRicep

Dependent Variable: LNRAINFALL Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNWCAR	0.357978	0.445631	0.803306	0.4277
LNCHINAGDP	0.02393	0.093174	0.256825	0.7990
LNRICEP	0.164896	0.090703	1.817982	0.0784
C	0.064953	7.220247	0.008996	0.9929
R-squared	0.458235			
Adjusted R-squared	0.407445			

Table A-12 Results of regression between lnRicep with lnChinaGDP, lnWCAR, and lnRainfall

Dependent Variable: LNRICEP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNRAINFALL	0.567717	0.312279	1.817982	0.0784
LNWCAR	-0.212444	0.834318	-0.254631	0.8006
LNCHINAGDP	0.115663	0.171851	0.673043	0.5058
C	4.44277	13.37413	0.332191	0.7419
R-squared	0.284908			
Adjusted R-squared	0.217868			

Table A-13 Results of multicollinearity test of simultaneous equation model No.3

Variables	R-squared	VIF
LNJAPANGDP	0.669	3.028
LNWCAR	0.788	4.719
LNRAINFALL	0.509	2.036
LNRICEP	0.302	1.434

The simultaneous equation model No.3 has no multicollinearity problem between lnJapanGDP, lnWCAR, lnRainfall and lnRicep with VIFs 3.028, 4.719, 2.036 and 1.434, respectively.

Table A-14 Results of regression between lnJapanGDP with lnWCAR, lnRainfall and lnRicep

Dependent Variable: LNJAPANGDP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNWCAR	2.60963	0.349896	7.458291	0.0000
LNRAINFALL	-0.72499	0.395345	-1.833815	0.0760
LNRICEP	-0.238671	0.211793	-1.126907	0.2682
C	-28.74673	4.841402	-5.937687	0.0000
R-squared	0.669725			
Adjusted R-squared	0.638762			

Table A-15 Results of regression between lnWCAR with lnChinaGDP, lnRainfall and lnRicep

Dependent Variable: LNWCAR Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNJAPANGDP	0.243258	0.032616	7.458291	0.0000
LNRAINFALL	0.394192	0.106041	3.717372	0.0008
LNRICEP	0.100258	0.063507	1.578702	0.1242
C	11.51527	0.669556	17.19837	0.0000
R-squared	0.788100			
Adjusted R-squared	0.768235			

Table A-16 Results of regression between lnRainfall with lnChinaGDP, lnWCAR, and lnRicep

Dependent Variable: LNRAINFALL Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNWCAR	0.765103	0.205818	3.717372	0.00080
LNJAPANGDP	-0.131169	0.071528	-1.833815	0.07600
LNRICEP	0.120835	0.089339	1.352553	0.18570
C	-5.314401	2.833796	-1.875365	0.06990
R-squared	0.508745			
Adjusted R-squared	0.462689			

Table A-17 Results of regression between lnRicep with lnChinaGDP, lnWCAR, and lnRainfall

Dependent Variable: LNRICEP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNRAINFALL	0.447528	0.330877	1.352553	0.1857
LNWCAR	0.720707	0.456519	1.578702	0.1242
LNJAPANGDP	-0.159928	0.141918	-1.126907	0.2682
C	-8.596643	5.540844	-1.551504	0.1306
R-squared	0.302467			
Adjusted R-squared	0.237073			

Table A-18 Result of simultaneous equations model No.3, Demand model with AR(1)

Dependent Variable: LNRUBBERQ Method: Least Squares Included observations: 35				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNESTP	-0.043548	0.05449	-0.79918	**0.4305**
LNJAPANGDP	0.162207	0.111243	1.458133	**0.1552**
LNWCAR	0.096554	0.181792	0.531126	**0.5992**
C	12.88251	3.788027	3.40085	0.0019
AR(1)	0.970113	0.020704	46.85729	0.0000
R-squared	0.991881		Durbin-Watson stat	2.052803
Adjusted R-squared	0.990798			

The results show that all independent variables in this demand model have no significant value.

Table A-19 Result of simultaneous equations model No.3, Supply model with AR(1)

Dependent Variable: LNRUBBERQ Method: Least Squares Included observations: 35				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNESTP	0.094694	0.1667	0.568049	**0.5742**
LNRAINFALL	-0.066504	0.151457	-0.439098	**0.6637**
LNRICEP	-0.12488	0.118862	-1.05063	**0.3018**
C	16.40269	1.085244	15.11428	0.0000
AR(1)	0.963831	0.017845	54.0117	0.0000
R-squared	0.99164		Durbin-Watson stat	1.805372
Adjusted R-squared	0.990525			

The results show that all independent variables in this supply model have no significant value.

Table A-20 Results of multicollinearity test of simultaneous equation model No.4

Variables	R-squared	VIF
LNUSAGDP	0.837868	**6.168**
LNWCAR	0.88241	**8.504**
LNRAINFALL	0.48791	1.953
LNRICEP	0.350666	1.540

The simultaneous equation model No.4 has a multicollinearity problem in the variables lnUSAGDP and lnWCAR with VIFs 6.168 and 8.504, respectively.

Table A-21 Results of regression between lnUSAGDP with lnWCAR, lnRainfall and lnRicep

Dependent Variable: LNUSAGDP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNWCAR	2.273188	0.202589	11.22068	0.0000
LNRAINFALL	-0.317519	0.228904	-1.387126	0.1750
LNRICEP	-0.237134	0.122627	-1.933774	0.0620
C	-25.79677	2.80316	-9.202745	0.0000
R-squared	0.837868			
Adjusted R-squared	0.822669			

Table A-22 Results of regression between lnWCAR with lnUSAGDP, lnRainfall and lnRicep

Dependent Variable: LNWCAR Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNUSAGDP	0.350761	0.03126	11.22068	0.0000
LNRAINFALL	0.232256	0.082979	2.798982	0.0086
LNRICEP	0.106595	0.047291	2.254043	0.0312
C	11.55813	0.496658	23.27181	0.0000
R-squared	0.88241			
Adjusted R-squared	0.871386			

Table A-23 Results of regression between lnRainfall with lnUSAGDP, lnWCAR, and lnRicep

Dependent Variable: LNRAINFALL Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNWCAR	0.846791	0.302535	2.798982	0.0086
LNUSAGDP	-0.17863	0.128777	-1.387126	0.1750
LNRICEP	0.116235	0.095006	1.223442	0.2301
C	-6.217264	3.861617	-1.610015	0.1172
R-squared	0.48791			
Adjusted R-squared	0.439902			

Table A-24 Results of regression between lnRicep with lnUSAGDP, lnWCAR, and lnRainfall

Dependent Variable: LNRICEP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNRAINFALL	0.384439	0.314228	1.223442	0.2301
LNWCAR	1.285401	0.570265	2.254043	0.0312
LNUSAGDP	-0.441235	0.228173	-1.933774	0.0620
C	-15.10531	6.796008	-2.222675	0.0334
R-squared	0.350666			
Adjusted R-squared	0.289791			

Table A-25 Results of multicollinearity test of simultaneous equation model No.5

Variables	R-squared	VIF
LNWGDP	0.467171	1.877
LNUSCARSALES	0.542625	2.186
LNRAINFALL	0.383603	1.622
LNRICEP	0.643599	2.806

The simultaneous equation model No.5 has no multicollinearity problem between lnWGDP, lnUSCarsales, lnRainfall and lnRicep with VIFs 1.877, 2.186, 1.622 and 2.806, respectively.

Table A-26 Results of regression between lnWGDP with lnUSCarsales, lnRainfall and lnRicep

Dependent Variable: LNWGDP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNUSCARSALES	1.734826	0.548546	3.162587	0.0034
LNRAINFALL	0.651862	0.373462	1.745459	0.0905
LNRICEP	0.832599	0.282171	2.950686	0.0059
C	-29.76473	9.451976	-3.149048	0.0035
R-squared	0.467171			
Adjusted R-squared	0.417218			

Table A-27 Results of regression between lnUSCarsales with lnWGDP, lnRainfall and lnRicep

Dependent Variable: LNUSCARSALES Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNWGDP	0.137265	0.043403	3.162587	0.0034
LNRAINFALL	0.077034	0.109091	0.706144	0.4852
LNRICEP	-0.361413	0.062706	-5.763622	0.0000
C	16.82748	0.640741	26.26251	0.0000
R-squared	0.542625			
Adjusted R-squared	0.499746			

Table A-28 Results of regression between lnRainfall with lnWGDP, lnUSCarsales and lnRicep

Dependent Variable: LNRAINFALL Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNUSCARSALES	0.199177	0.282063	0.706144	0.4852
LNWGDP	0.133357	0.076403	1.745459	0.0905
LNRICEP	0.280817	0.135116	2.078348	0.0458
C	1.401682	4.886674	0.286838	0.7761
R-squared	0.383603			
Adjusted R-squared	0.325816			

Table A-29 Results of regression between lnRicep with lnWGDP, lnUSCarsales and lnRainfall

Dependent Variable: LNRICEP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNRAINFALL	0.423519	0.203777	2.078348	0.0458
LNUSCARSALES	-1.409323	0.24452	-5.763622	0.0000
LNWGDP	0.256889	0.087061	2.950686	0.0059
C	23.63904	4.317904	5.474658	0.0000
R-squared	0.643599			
Adjusted R-squared	0.610186			

Table A-30 Result of simultaneous equations model No.5, Demand model with AR(1)

Dependent Variable: LNRUBBERQ Method: Least Squares Included observations: 35				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNESTP	-0.02166	0.049783	-0.435093	**0.6666**
LNWGDP	0.206872	0.2331	0.887482	**0.3819**
LNUSCARSALES	0.180623	0.11871	1.521545	**0.1386**
C	11.02505	3.060269	3.602641	0.0011
AR(1)	0.963468	0.018903	50.96973	0.0000
R-squared	0.992054	Durbin-Watson stat		1.95178
Adjusted R-squared	0.990994			

The results show that all independent variables in this demand model have no significant value.

Table A-31 Result of simultaneous equations model No.5, Supply model with AR(1)

Dependent Variable: LNRUBBERQ Method: Least Squares Included observations: 35				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNESTP	0.775609	0.530147	1.463006	**0.1539**
LNRAINFALL	-0.809029	0.564716	-1.432628	**0.1623**
LNRICEP	-0.610469	0.376746	-1.620372	**0.1156**
C	19.66606	2.51782	7.810748	0.0000
AR(1)	0.96498	0.021125	45.67939	0.0000
R-squared	0.992112	Durbin-Watson stat		1.919745
Adjusted R-squared	0.991061			

The results show that all independent variables in this supply model have no significant value.

Table A-32 Results of multicollinearity test of simultaneous equation model No.6

Variables	R-squared	VIF
LNCHINAGDP	0.565	2.297
LNUSCARSALES	0.549	2.217
LNRAINFALL	0.448	1.812
LNRICEP	0.656	2.907

The simultaneous equation model No.6 has no multicollinearity problem between lnChinaGDP, lnUSCarsales, lnRainfall and lnRicep with VIFs 2.297, 2.217, 1.812 and 2.907, respectively.

Table A-33 Results of regression between lnChinaGDP with lnUSCarsales, lnRainfall and lnRicep

Dependent Variable: LNCHINAGDP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNUSCARSALES	3.580979	1.100538	3.253843	0.0027
LNRAINFALL	2.002754	0.749269	2.672944	0.0117
LNRICEP	1.805187	0.566115	3.18873	0.0032
C	-77.70523	18.96332	-4.09766	0.0003
R-squared	0.564679			
Adjusted R-squared	0.523868			

Table A-34 Results of regression between lnUSCarsales with lnChinaGDP, lnRainfall and lnRicep

Dependent Variable: LNUSCARSALES Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNCHINAGDP	0.069424	0.021336	3.253843	0.0027
LNRAINFALL	0.025183	0.1153	0.218414	0.8285
LNRICEP	-0.36905	0.0627	-5.88604	0.0000
C	17.96124	0.7405	24.25554	0.0000
R-squared	0.548914			
Adjusted R-squared	0.506625			

Table A-35 Results of regression between lnRainfall with lnChinaGDP, lnUSCarsales and lnRicep

Dependent Variable: LNRAINFALL Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNUSCARSALES	0.059109	0.270629	0.218414	0.8285
LNCHINAGDP	0.091134	0.034095	2.672944	0.0117
LNRICEP	0.186315	0.134657	1.38362	0.1761
C	4.782719	4.922915	0.971522	0.3386
R-squared	0.448133			
Adjusted R-squared	0.396396			

Table A-36 Results of regression between lnRicep with lnChinaGDP, lnUSCarsales and lnRainfall

Dependent Variable: LNRICEP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNRAINFALL	0.302972	0.218971	1.38362	0.1761
LNUSCARSALES	-1.4086	0.239312	-5.88604	0.0000
LNCHINAGDP	0.133577	0.04189	3.18873	0.0032
C	25.81813	4.443126	5.810802	0.0000
R-squared	0.655951			
Adjusted R-squared	0.623696			

Table A-37 Result of Simultaneous equation model No.6, Demand model with AR(1)

Dependent Variable: LNRUBBERQ Method: Least Squares Included observations: 35				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNESTP	-0.008240	0.053806	-0.15317	**0.8793**
LNCHINAGDP	**-0.016500**	0.141207	-0.11688	**0.9077**
LNUSCARSALES	0.183667	0.120376	1.525785	**0.1375**
C	13.22284	3.069123	4.308345	0.0002
AR(1)	0.966942	0.022124	43.70603	0.0000
R-squared	0.991859		Durbin-Watson stat	1.903967
Adjusted R-squared	0.990773			

The results show the wrong sign of the lnCHINAGDP's coefficient and all independent variables in this demand model have no significant value.

Table A-38 Result of Simultaneous equation model No.6, Supply model with AR(1)

Dependent Variable: LNRUBBERQ Method: Least Squares Included observations: 35				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNESTP	**-0.022690**	0.62513	-0.03629	**0.9713**
LNRAINFALL	**0.033744**	0.57832	0.058348	**0.9539**
LNRICEP	-0.0503	0.402519	-0.12497	**0.9014**
C	16.30833	1.587097	10.27557	0.0000
AR(1)	0.967506	0.022431	43.1318	0.0000
R-squared	0.991551		Durbin-Watson stat	1.789099
Adjusted R-squared	0.990424			

The results show the wrong sign of the lnEstp and lnRainfall's coefficient and all independent variables in this supply model have no significant value.

Table A-39 Results of multicollinearity test of simultaneous equation model No.7

Variables	R-squared	VIF
LNJAPANGDP	0.308	1.445
LNUSCARSALES	0.541	2.177
LNRAINFALL	0.333	1.499
LNRICEP	0.603	2.521

The simultaneous equation model No.7 has no multicollinearity problem between lnJapanGDP, lnUSCarsales, lnRainfall and lnRicep with VIFs 1.445, 2.177, 1.499 and 2.521, respectively.

Table A-40 Results of regression between lnJapanGDP with lnUSCarsales, lnRainfall and lnRicep

Dependent Variable: LNJAPANGDP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNUSCARSALES	2.361431	0.753843	3.132525	0.0037
LNRAINFALL	0.315535	0.513231	0.614801	0.5430
LNRICEP	0.828862	0.387775	2.137481	0.0403
C	-35.92317	12.98942	-2.765571	0.0094
R-squared	0.307849			
Adjusted R-squared	0.24296			

Table A-41 Results of regression between lnUSCarsales with lnJapanGDP, lnRainfall and lnRicep

Dependent Variable: LNUSCARSALES Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNJAPANGDP	0.099382	0.031726	3.132525	0.0037
LNRAINFALL	0.135907	0.103147	1.317606	0.1970
LNRICEP	-0.33062	0.061774	-5.3521	0.0000
C	16.36959	0.651285	25.13431	0.0000
R-squared	0.540555			
Adjusted R-squared	0.497482			

Table A-42 Results of regression between lnRainfall with lnJapanGDP, lnUSCarsales and lnRicep

Dependent Variable: LNRAINFALL Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNUSCARSALES	0.378647	0.287375	1.317606	0.1970
LNJAPANGDP	0.036997	0.060178	0.614801	0.5430
LNRICEP	0.393482	0.123734	3.180051	0.0033
C	-1.45023	4.944318	-0.29331	0.7712
R-squared	0.332799			
Adjusted R-squared	0.270249			

Table A-43 Results of regression between lnRicep with lnJapanGDP, lnUSCarsales and lnRainfall

Dependent Variable: LNRICEP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNRAINFALL	0.610281	0.191909	3.180051	0.0033
LNUSCARSALES	-1.42865	0.266933	-5.3521	0.0000
LNJAPANGDP	0.150734	0.070519	2.137481	0.0403
C	23.21722	4.601368	5.04572	0.0000
R-squared	0.603273			
Adjusted R-squared	0.566079			

Table A-44 Result of Simultaneous equation model No.7, Demand model

Dependent Variable: LNRUBBERQ Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNESTP	**0.206955**	0.074781	2.767486	0.0093
LNJAPANGDP	0.965405	0.068856	14.02056	0.0000
LNUSCARSALES	0.584981	0.226946	2.577623	0.0148
C	-6.5561	3.651044	-1.79568	0.0820
R-squared	0.945906	Durbin-Watson stat		0.760595
Adjusted R-squared	0.940835			

The results show the wrong sign of the lnESTP's coefficient.

Table A-45 Results of multicollinearity test of simultaneous equation model No.9

Variables	R-squared	VIF
LNWGDP	0.873117	**7.881**
LNWCAR	0.897418	**9.748**
LNRAINFALL	0.487446	1.951
LNPALMOILP	0.352702	1.545

The simultaneous equation model No.9 has a multicollinearity problem in the variables lnWGDP and lnWCAR with VIFs 7.881 and 9.748, respectively. However, lnRainfall and lnPalmoilp have no multicollinearity problem with VIFs 1.951 and 1.545, respectively.

Table A-46 Results of regression between lnWGDP with lnWCAR, lnRainfall and lnPalmoilp

Dependent Variable: LNWGDP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNWCAR	2.196835	0.179375	12.24719	0.0000
LNRAINFALL	-0.137948	0.207726	-0.664086	0.5114
LNPALMOILP	-0.135147	0.103811	-1.301848	0.2023
C	-28.07097	2.493149	-11.25925	0.0000
R-squared	0.873117			
Adjusted R-squared	0.861222			

Table A-47 Results of regression between lnWCAR with lnWGDP, lnRainfall and lnPalmoilp

Dependent Variable: LNWCAR Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNWGDP	0.375162	0.030633	12.24719	0.0000
LNRAINFALL	0.15586	0.081923	1.902521	0.0661
LNPALMOILP	0.068672	0.042314	1.622914	0.1144
C	12.71804	0.460493	27.61832	0.0000
R-squared	0.897418			
Adjusted R-squared	0.887801			

Table A-48 Results of regression between lnRainfall with lnWGDP, lnWCAR, and lnPalmoilp

Dependent Variable: LNRAINFALL Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNWCAR	0.651984	0.342695	1.902521	0.0661
LNWGDP	-0.09855	0.148394	-0.66409	0.5114
LNPALMOILP	0.169228	0.08492	1.992781	0.0549
C	-4.19911	4.634692	-0.90602	0.3717
R-squared	0.487446			
Adjusted R-squared	0.439394			

Table A-49 Results of regression between lnPalmoilp with lnWGDP, lnWCAR, and lnRainfall

Dependent Variable: LNPALMOILP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNRAINFALL	0.652369	0.327366	1.992781	0.0549
LNWCAR	1.107408	0.682358	1.622914	0.1144
LNWGDP	-0.37218	0.285886	-1.30185	0.2023
C	-14.8064	8.836267	-1.67564	0.1036
R-squared	0.352702			
Adjusted R-squared	0.292018			

Table A-50 Results of multicollinearity test of simultaneous equation model No.10

Variables	R-squared	VIF
LNCHINAGDP	0.930639	**14.417**
LNWCAR	0.930293	**14.346**
LNRAINFALL	0.480763	1.926
LNPALMOILP	0.332691	1.499

The simultaneous equation model No.10 has a multicollinearity problem in the variables lnChinaGDP and lnWCAR with VIFs 14.417 and 14.346, respectively. However, lnRainfall and lnPalmoilp have no multicollinearity problem with VIFs 1.926 and 1.499, respectively.

Table A-51 Results of regression between lnWGDP with lnWCAR, lnRainfall and lnPalmoilp

Dependent Variable: LNCHINAGDP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNWCAR	4.520558	0.294373	15.35656	0.0000
LNRAINFALL	0.052225	0.3409	0.153199	0.8792
LNPALMOILP	0.14094	0.170366	0.82728	0.4142
C	-73.71323	4.091526	-18.01607	0.0000
R-squared	0.930639			
Adjusted R-squared	0.924136			

Table A-52 Results of regression between lnWCAR with lnChinaGDP, lnRainfall and lnPalmoilp

Dependent Variable: LNWCAR Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNCHINAGDP	0.194781	0.012684	15.35656	0.0000
LNRAINFALL	0.060571	0.069974	0.865617	0.3931
LNPALMOILP	-0.015241	0.035638	-0.427658	0.6718
C	15.84397	0.43926	36.06971	0.0000
R-squared	0.930293			
Adjusted R-squared	0.923758			

Table A-53 Results of regression between lnRainfall with lnChinaGDP, lnWCAR, and lnPalmoilp

Dependent Variable: LNRAINFALL Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNWCAR	0.377734	0.436376	0.865617	0.3931
LNCHINAGDP	0.014033	0.091602	0.153199	0.8792
lnPalmoilp	0.182948	0.083186	2.199267	0.0352
C	-0.41706	7.079509	-0.05891	0.9534
R-squared	0.480763			
Adjusted R-squared	0.432084			

Table A-54 Results of regression between lnPalmoilp with lnChinaGDP, lnWCAR, and lnRainfall

Dependent Variable: LNPALMOILP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNRAINFALL	0.717706	0.326339	2.199267	0.0352
LNWCAR	-0.37287	0.871883	-0.42766	0.6718
LNCHINAGDP	0.14857	0.179588	0.82728	0.4142
C	6.457835	13.97629	0.462056	0.6472
R-squared	0.332691			
Adjusted R-squared	0.270131			

Table A-55 Results of multicollinearity test of simultaneous equation model No.11

Variables	R-squared	VIF
LNUSAGDP	0.848838	**6.615**
LNWCAR	0.889663	**9.063**
LNRAINFALL	0.498934	1.996
LNPALMOILP	0.431022	1.758

The simultaneous equation model No.11 has a multicollinearity problem in the variables lnUSAGDP and lnWCAR with VIFs 6.615 and 9.063, respectively. However, lnRainfall and lnPalmoilp have no multicollinearity problem with VIFs 1.996 and 1.758, respectively.

Table A-56 Results of regression between lnUSAGDP with lnWCAR, lnRainfall and lnPalmoilp

Dependent Variable: LNUSAGDP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNWCAR	2.285096	0.195084	11.71337	0.0000
LNRAINFALL	-0.24591	0.225919	-1.088488	0.2845
LNPALMOILP	-0.284124	0.112903	-2.516529	0.0171
C	-26.11486	2.711501	-9.631144	0.0000
R-squared	0.848838			
Adjusted R-squared	0.834666			

Table A-57 Results of regression between lnWCAR with lnUSAGDP, lnRainfall and lnPalmoilp

Dependent Variable: LNWCAR Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNUSAGDP	0.354855	0.030295	11.71337	0.0000
LNRAINFALL	0.199239	0.08354	2.384958	0.0232
LNPALMOILP	0.120152	0.043819	2.741985	0.0099
C	11.61917	0.482077	24.10232	0.0000
R-squared	0.889663			
Adjusted R-squared	0.879319			

Table A-58 Results of regression between lnRainfall with lnUSAGDP, lnWCAR, and lnPalmoilp

Dependent Variable: LNRAINFALL Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNWCAR	0.757503	0.317617	2.384958	0.0232
LNUSAGDP	-0.14519	0.133386	-1.08849	0.2845
LNPALMOILP	0.137203	0.0918	1.494579	0.1448
C	-5.19229	4.010153	-1.29479	0.2047
R-squared	0.498934			
Adjusted R-squared	0.451959			

Table A-59 Results of regression between lnPalmoilp with lnUSAGDP, lnWCAR, and lnRainfall

Dependent Variable: LNPALMOILP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNRAINFALL	0.475577	0.318201	1.494579	0.1448
LNWCAR	1.583431	0.577476	2.741985	0.0099
LNUSAGDP	-0.58147	0.231058	-2.51653	0.0171
C	-19.0164	6.881947	-2.76323	0.0094
R-squared	0.431022			
Adjusted R-squared	0.37768			

Table A-60 Results of multicollinearity test of simultaneous equation model No.12

Variables	R-squared	VIF
LNJAPANGDP	0.713666	3.492
LNWCAR	0.813307	**5.356**
LNRAINFALL	0.50891	2.036
LNPALMOILP	0.431654	1.759

The simultaneous equation model No.12 has a multicollinearity problem in the variable lnWCAR with VIFs 5.356. However, lnJapanGDP, lnRainfall and lnPalmoilp have no multicollinearity problem with VIFs 3.492, 2.036and 1.759, respectively.

Table A-61 Results of regression between lnJapanGDP with lnWCAR, lnRainfall and lnPalmoilp

Dependent Variable: LNJAPANGDP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNWCAR	2.679231	0.324905	8.246203	0.0000
LNRAINFALL	-0.513004	0.376258	-1.363437	0.1823
LNPALMOILP	-0.474787	0.188036	-2.524986	0.0167
C	-29.93354	4.515891	-6.628491	0.0000
R-squared	0.713666			
Adjusted R-squared	0.686822			

Table A-62 Results of regression between lnWCAR with lnJapanGDP, lnRainfall and lnPalmoilp

Dependent Variable: LNWCAR Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNJAPANGDP	0.253804	0.030778	8.246203	0.0000
LNRAINFALL	0.31967	0.104865	3.048407	0.0046
LNPALMOILP	0.153208	0.057299	2.673821	0.0117
C	11.57722	0.629166	18.4009	0.0000
R-squared	0.813307			
Adjusted R-squared	0.795804			

Table A-63 Results of regression between lnRainfall with lnJapanGDP, lnWCAR, and lnPalmoilp

Dependent Variable: LNRAINFALL Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNWCAR	0.703995	0.230939	3.048407	0.0046
LNJAPANGDP	-0.10702	0.078495	-1.36344	0.1823
LNPALMOILP	0.124088	0.091459	1.356767	0.1844
C	-4.57639	3.07269	-1.48937	0.1462
R-squared	0.50891			
Adjusted R-squared	0.462871			

Table A-64 Results of regression between lnPalmoilp with lnJapanGDP, lnWCAR, and lnRainfall

Dependent Variable: LNPALMOILP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNRAINFALL	0.438369	0.323098	1.356767	0.1844
LNWCAR	1.191952	0.445786	2.673821	0.0117
LNJAPANGDP	-0.34992	0.138582	-2.52499	0.0167
C	-14.3015	5.410579	-2.64325	0.0126
R-squared	0.431654			
Adjusted R-squared	0.378372			

Table A-65 Results of multicollinearity test of simultaneous equation model No.13

Variables	R-squared	VIF
LNWGDP	0.341795	1.519
LNUSCARSALES	0.203009	1.255
LNRAINFALL	0.429509	1.753
LNPALMOILP	0.401023	1.670

The simultaneous equation model No.13 has no multicollinearity problem between lnWGDP, lnUSCarsales, lnRainfall and lnPalmoilp with VIFs 1.519, 1.255, 1.753 and 1.670, respectively.

Table A-66 Results of regression between lnWGDP with lnUSCarsales, lnRainfall and lnPalmoilp

Dependent Variable: LNWGDP Sample: 1977 2012 Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNUSCARSALES	0.887346	0.505353	1.755893	0.0887
LNRAINFALL	1.054269	0.411273	2.563429	0.0153
LNPALMOILP	0.242594	0.248546	0.976054	0.3364
C	-15.5381	8.796221	-1.766451	0.0869
R-squared	0.341795			
Adjusted R-squared	0.280088			

Table A-67 Results of regression between lnUSCarsales with lnWGDP, lnRainfall and lnPalmoilp

Dependent Variable: LNUSCARSALES Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNWGDP	0.099039	0.056404	1.755893	0.0887
LNRAINFALL	0.007114	0.150844	0.047162	0.9627
LNPALMOILP	-0.18152	0.077913	-2.329776	0.0263
C	16.74178	0.847904	19.7449	0.0000
R-squared	0.203009			
Adjusted R-squared	0.128291			

Table A-68 Results of regression between lnRainfall with lnWGDP, lnUSCarsales and lnPalmoilp

Dependent Variable: LNRAINFALL Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNUSCARSALES	0.00977	0.207154	0.047162	0.9627
LNWGDP	0.161595	0.063039	2.563429	0.0153
LNPALMOILP	0.239964	0.089169	2.691109	0.0112
C	4.39192	3.52324	1.246557	0.2216
R-squared	0.429509			
Adjusted R-squared	0.376026			

Table A-69 Results of regression between lnPalmoilp with lnWGDP, lnUSCarsales and lnRainfall

Dependent Variable: LNPALMOILP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNRAINFALL	0.769068	0.285781	2.691109	0.0112
LNUSCARSALES	-0.79893	0.342921	-2.329776	0.0263
LNWGDP	0.119173	0.122096	0.976054	0.3364
C	12.7071	6.055533	2.098428	0.0438
R-squared	0.401023			
Adjusted R-squared	0.344869			

Table A-70 Result of Simultaneous equation model No.13, Demand model with AR(1)

Dependent Variable: LNRUBBERQ Method: Least Squares Included observations: 35				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNESTP	-0.035696	0.047926	-0.744829	**0.4622**
LNWGDP	0.214613	0.220239	0.974456	**0.3376**
LNUSCARSALES	0.175775	0.117337	1.498033	**0.1446**
C	11.17703	3.062167	3.650041	0.0010
AR(1)	0.964393	0.018775	51.36591	0.0000
R-squared	0.992149	Durbin-Watson stat		1.971725
Adjusted R-squared	0.991103			

The results show that all independent variables in this demand model have no significant value.

Table A-71 Result of Simultaneous equation model No.13, Supply model with AR(1)

Dependent Variable: LNRUBBERQ Method: Least Squares Included observations: 35				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNESTP	-0.175502	0.189423	-0.926511	**0.3616**
LNRAINFALL	0.188213	0.188802	0.996884	**0.3268**
LNPALMOILP	0.033062	0.105849	0.312348	**0.7569**
C	15.8484	1.296491	12.22407	0.0000
AR(1)	0.967703	0.015338	63.08996	0.0000
R-squared	0.991860	Durbin-Watson stat		1.862995
Adjusted R-squared	0.990775			

The results show that all independent variables in this supply model have no significant value.

Table A-72 Results of multicollinearity test of simultaneous equation model No.14

Variables	R-squared	VIF
LNCHINAGDP	0.488	1.954
LNUSCARSALES	0.229	1.298
LNRAINFALL	0.469	1.885
LNPALMOILP	0.448	1.817

The simultaneous equation model No.14 has no multicollinearity problem between lnChinaGDP, lnUSCarsales, lnRainfall and lnPalmoilp with VIFs 1.954, 1.298, 1.885 and 1.817, respectively.

Table A-73 Results of regression between lnChinaGDP with lnUSCarsales, lnRainfall and lnPalmoilp

Dependent Variable: LNCHINAGDP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNUSCARSALES	2.05131	0.989042	2.074037	0.0462
LNRAINFALL	2.477966	0.804916	3.078541	0.0042
LNPALMOILP	0.957154	0.486437	1.967682	0.0578
C	-51.6799	17.21536	-3.001964	0.0052
R-squared	0.488271			
Adjusted R-squared	0.440297			

Table A-74 Results of regression between lnUSCarsales with lnChinaGDP, lnRainfall and lnPalmoilp

Dependent Variable: LNUSCARSALES Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNCHINAGDP	0.057766	0.027852	2.074037	0.0462
LNRAINFALL	-0.035359	0.153654	-0.230122	0.8195
LNPALMOILP	-0.207499	0.078257	-2.651505	0.0124
C	17.67798	0.964557	18.32757	0.0000
R-squared	0.22976			
Adjusted R-squared	0.15755			

Table A-75 Results of regression between lnRainfall with lnChinaGDP, lnUSCarsales and lnPalmoilp

Dependent Variable: LNRAINFALL Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNUSCARSALES	-0.046725	0.203043	-0.230122	0.8195
LNCHINAGDP	0.092211	0.029953	3.078541	0.0042
LNPALMOILP	0.171345	0.094621	1.810857	0.0796
C	6.514695	3.578848	1.820333	0.0781
R-squared	0.469482			
Adjusted R-squared	0.419746			

Table A-76 Results of regression between lnPalmoilp with lnChinaGDP, lnUSCarsales and lnRainfall

Dependent Variable: LNPALMOILP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNRAINFALL	0.542472	0.299567	1.810857	0.0796
LNUSCARSALES	-0.868091	0.327396	-2.651505	0.0124
LNCHINAGDP	0.112765	0.057309	1.967682	0.0578
C	15.79971	6.078499	2.599279	0.0140
R-squared	0.449765			
Adjusted R-squared	0.398181			

Table A-77 Result of Simultaneous equation model No.14, Demand model with AR(1)

Dependent Variable: LNRUBBERQ Method: Least Squares Included observations: 35				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNESTP	-0.023512	0.055051	-0.427095	**0.6724**
LNCHINAGDP	-0.002548	0.143229	-0.017788	**0.9859**
LNUSCARSALES	0.175833	0.120498	1.459222	**0.1549**
C	13.32489	3.034258	4.391483	0.0001
AR(1)	0.966647	0.022386	43.18052	0.0000
R-squared	0.991901	Durbin-Watson stat		1.893023
Adjusted R-squared	0.990822			

The results show that all independent variables in this demand model have no significant value.

Table A-78 Result of Simultaneous equation model No.14, Supply model with AR(1)

Dependent Variable: LNRUBBERQ Method: Least Squares Included observations: 35				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNESTP	-0.30045	0.193923	-1.5493	**0.1318**
LNRAINFALL	0.293956	0.184389	1.594217	**0.1214**
LNPALMOILP	0.060969	0.086326	0.706266	**0.4855**
C	16.40226	1.769479	9.26954	0.0000
AR(1)	0.974608	0.015191	64.15879	0.0000
R-squared	0.992257	Durbin-Watson stat		2.062185
Adjusted R-squared	0.991225			

The results show that all independent variables in this supply model have no significant value.

Table A-79 Results of multicollinearity test of simultaneous equation model No.15

Variables	R-squared	VIF
LNJAPANGDP	0.209	1.265
LNUSCARSALES	0.228	1.295
LNRAINFALL	0.367	1.580
LNPALMOILP	0.383	1.622

The simultaneous equation model No.15 has no multicollinearity problem between lnJapanGDP, lnUSCarsales, lnRainfall and lnPalmoilp with VIFs 1.265, 1.295, 1.580 and 1.622, respectively.

Table A-80 Results of regression between lnJapanGDP with lnUSCarsales, lnRainfall and lnPalmoilp

Dependent Variable: LNJAPANGDP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNUSCARSALES	1.370881	0.667845	2.052694	0.0484
LNRAINFALL	0.90571	0.543514	1.666397	0.1054
LNPALMOILP	0.035748	0.328464	0.108833	0.9140
C	-19.46031	11.62457	-1.67407	0.1039
R-squared	0.209319			
Adjusted R-squared	0.135193			

Table A-81 Results of regression between lnUSCarsales with lnJapanGDP, lnRainfall and lnPalmoilp

Dependent Variable: LNUSCARSALES Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNJAPANGDP	0.084875	0.041348	2.052694	0.0484
LNRAINFALL	0.031174	0.140876	0.221289	0.8263
LNPALMOILP	-0.155612	0.076977	-2.02155	0.0517
C	16.38004	0.845229	19.37941	0.0000
R-squared	0.227887			
Adjusted R-squared	0.155501			

Table A-82 Results of regression between lnRainfall with lnJapanGDP, lnUSCarsales and lnPalmoilp

Dependent Variable: LNRAINFALL Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNUSCARSALES	0.049013	0.221487	0.221289	0.8263
LNJAPANGDP	0.088161	0.052905	1.666397	0.1054
LNPALMOILP	0.306472	0.087009	3.522326	0.0013
C	3.801911	3.722062	1.021453	0.3147
R-squared	0.367266			
Adjusted R-squared	0.307948			

Table A-83 Results of regression between lnPalmoilp with lnJapanGDP, lnUSCarsales and lnRainfall

Dependent Variable: LNPALMOILP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNRAINFALL	0.911629	0.258815	3.522326	0.0013
LNUSCARSALES	-0.727745	0.359994	-2.02155	0.0517
LNJAPANGDP	0.010351	0.095105	0.108833	0.9140
C	11.37585	6.205543	1.833176	0.0761
R-squared	0.383419			
Adjusted R-squared	0.325614			

Table A-84 Result of Simultaneous equation model No.15, Demand model

Dependent Variable: LNRUBBERQ Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNESTP	**0.229276**	0.071511	3.206187	0.0030
LNJAPANGDP	0.951383	0.066297	14.35027	0.0000
LNUSCARSALES	0.617026	0.219181	2.815142	0.0083
C	-7.09512	3.5252	-2.01269	0.0526
R-squared	0.949259	Durbin-Watson stat		0.776866
Adjusted R-squared	0.944502			

The results show the wrong sign of the lnESTP's coefficient.

Table A-85 Results of multicollinearity test of simultaneous equation model No.16

Variables	R-squared	VIF
LNUSAGDP	0.317101	1.464
LNUSCARSALES	0.253454	1.340
LNRAINFALL	0.410005	1.695
LNPALMOILP	0.390497	1.641

The simultaneous equation model No.16 has no multicollinearity problem between lnUSAGDP, lnUSCarsales, lnRainfall and lnPalmoilp with VIFs 1.464, 1.340, 1.695 and 1.641, respectively.

Table A-86 Results of regression between lnUSAGDP with lnUSCarsales, lnRainfall and lnPalmoilp

Dependent Variable: LNUSAGDP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNUSCARSALES	1.197795	0.512902	2.335331	0.0260
LNRAINFALL	0.960606	0.417416	2.301314	0.0280
LNPALMOILP	0.156242	0.252259	0.619373	0.5401
C	-17.65871	8.927613	-1.97799	0.0566
R-squared	0.317101			
Adjusted R-squared	0.253079			

Table A-87 Results of regression between lnUSCarsales with lnUSAGDP, lnRainfall and lnPalmoilp

Dependent Variable: LNUSCARSALES Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNUSAGDP	0.121568	0.052056	2.335331	0.0260
LNRAINFALL	-0.012311	0.143547	-0.08576	0.9322
LNPALMOILP	-0.166519	0.075295	-2.21156	0.0343
C	16.38738	0.828357	19.78299	0.0000
R-squared	0.253454			
Adjusted R-squared	0.183465			

Table A-88 Results of regression between lnRainfall with lnUSAGDP, lnUSCarsales and lnPalmoilp

Dependent Variable: LNRAINFALL Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNUSCARSALES	-0.018665	0.217649	-0.08576	0.9322
LNUSAGDP	0.147824	0.064234	2.301314	0.0280
LNPALMOILP	0.265614	0.087779	3.025951	0.0049
C	4.555724	3.621605	1.25793	0.2175
R-squared	0.410005			
Adjusted R-squared	0.354692			

Table A-89 Results of regression between lnPalmoilp with lnUSAGDP, lnUSCarsales and lnRainfall

Dependent Variable: LNPALMOILP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNRAINFALL	0.837598	0.276805	3.025951	0.0049
LNUSCARSALES	-0.79618	0.360009	-2.21156	0.0343
LNUSAGDP	0.075819	0.122413	0.619373	0.5401
C	12.38501	6.213891	1.993117	0.0548
R-squared	0.390497			
Adjusted R-squared	0.333357			

Table A-90 Result of Simultaneous equation model No.16, Demand model with AR(1)

Dependent Variable: LNRUBBERQ Method: Least Squares Included observations: 35 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNESTP	-0.03319	0.050521	-0.65694	0.5162
LNUSAGDP	1.426723	0.173877	8.205354	0.0000
LNUSCARSALES	0.051843	0.145933	0.355256	0.7249
C	-0.96572	2.51217	-0.38442	0.7034
AR(1)	0.797802	0.100345	7.950594	0.0000
R-squared	0.989801		Durbin-Watson stat	1.479855
Adjusted R-squared	0.988441			

The results show that the variables LNESTP and LNUSCARSALES in this demand model have no significant value. However, the variable LNUSAGDP is significant at 1 percent level with p-value of 0.00.

Table A-91 Result of Simultaneous equation model No.16, Supply model with AR(1)

Dependent Variable: LNRUBBERQ Method: Least Squares Included observations: 35 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNESTP	-0.37639	0.190133	-1.97961	0.0570
LNRAINFALL	0.413375	0.205494	2.011612	0.0533
LNPALMOILP	0.148738	0.111748	1.331014	**0.1932**
C	14.84994	1.304764	11.38132	0.0000
AR(1)	0.965915	0.013887	69.55532	0.0000
R-squared	0.992595		Durbin-Watson stat	2.003213
Adjusted R-squared	0.991608			

The results show that the variables LNESTP and lnRainfall in this supply model are significant at 10 percent level with p-value of 0.06 and 0.05, respectively. However, the variable lnPalmoilp has no significant value.

Table A-92 Results of multicollinearity test of simultaneous equation model No.17

Variables	R-squared	VIF
LNWGDP	0.883	**8.578**
LNWCAR	0.916	**11.906**
LNUSCARSALES	0.630	2.706
LNRAINFALL	0.497	1.988
LNRICEP	0.800	4.989
LNPALMOILP	0.683	3.154

The simultaneous equation model No.17 has a multicollinearity problem in the variables lnWGDP and lnWCAR with VIFs 8.578 and 11.906, respectively. However, lnUSCarsales, lnRainfall, LNRICEP and lnPalmoilp have no multicollinearity problem with VIFs 2.706, 1.988, 4.989 and 3.154, respectively.

Table A-93 Results of regression between lnWGDP with lnUSCarsales, lnWCAR, lnRainfall, lnRicep and lnPalmoilp

Dependent Variable: LNWGDP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNWCAR	2.253094	0.223212	10.09395	0.0000
LNUSCARSALES	-0.205661	0.335671	-0.612687	0.5447
LNRAINFALL	-0.16962	0.206703	-0.820597	0.4183
LNRICEP	0.137367	0.203464	0.675141	0.5048
LNPALMOILP	-0.267681	0.142538	-1.877962	0.0701
C	-25.38171	4.674464	-5.429865	0.0000
R-squared	0.883422			
Adjusted R-squared	0.863992			

Table A-94 Results of regression between lnWCAR with lnUSCarsales, lnWGDP, lnRainfall, lnRicep and lnPalmoilp

Dependent Variable: LNWCAR Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNWGDP	0.342877	0.033969	10.09395	0.0000
LNUSCARSALES	0.276094	0.12174	2.267902	0.0307
LNRAINFALL	0.151063	0.076729	1.96878	0.0583
LNRICEP	0.050124	0.079447	0.630911	0.5329
LNPALMOILP	0.085926	0.05665	1.516781	0.1398
C	8.077846	2.101943	3.843037	0.0006
R-squared	0.916011			
Adjusted R-squared	0.902013			

Table A-95 Results of regression between lnUSCarsales with lnWGDP, lnWCAR, lnRainfall, lnRicep and lnPalmoilp

Dependent Variable: LNUSCARSALES Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNWGDP	-0.06009	0.098076	-0.61269	0.5447
LNWCAR	0.530088	0.233735	2.267902	0.0307
LNRAINFALL	-0.05273	0.112567	-0.4684	0.6429
LNRICEP	-0.40311	0.082841	-4.86607	0.0000
LNPALMOILP	0.046373	0.081009	0.57244	0.5713
C	10.14402	3.037872	3.339185	0.0023
R-squared	0.630471			
Adjusted R-squared	0.568883			

Table A-96 Results of regression between lnRainfall with lnUSCarsales, lnWCAR, lnWGDP, lnRicep and lnPalmoilp

Dependent Variable: LNRAINFALL Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNUSCARSALES	-0.1377	0.293971	-0.4684	0.6429
LNWGDP	-0.12943	0.157722	-0.8206	0.4183
LNWCAR	0.757431	0.384721	1.96878	0.0583
LNRICEP	0.022681	0.179027	0.12669	0.9000
LNPALMOILP	0.118134	0.129846	0.909807	0.3702
C	-3.31928	5.717624	-0.58053	0.5659
R-squared	0.496995			
Adjusted R-squared	0.41316			

Table A-97 Results of regression between lnRicep with lnUSCarsales, lnWCAR, lnRainfall, lnWGDP and lnPalmoilp

Dependent Variable: LNRICEP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNRAINFALL	0.023576	0.186092	0.12669	0.9000
LNUSCARSALES	-1.09428	0.22488	-4.86607	0.0000
LNWGDP	0.108952	0.161377	0.675141	0.5048
LNWCAR	0.261242	0.414071	0.630911	0.5329
LNPALMOILP	0.439063	0.107624	4.079597	0.0003
C	15.35477	5.148217	2.982542	0.0056
R-squared	0.799547			
Adjusted R-squared	0.766138			

Table A-98 Results of regression between lnPalmoilp with lnUSCarsales, lnWCAR, lnRainfall, lnRicep and lnWGDP

Dependent Variable: LNPALMOILP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNRICEP	0.812681	0.199206	4.079597	0.0003
LNRAINFALL	0.22729	0.249822	0.909807	0.3702
LNUSCARSALES	0.233001	0.407032	0.57244	0.5713
LNWGDP	-0.39298	0.209256	-1.87796	0.0701
LNWCAR	0.828918	0.546498	1.516781	0.1398
C	-15.087	7.484448	-2.01578	0.0529
R-squared	0.682957			
Adjusted R-squared	0.630116			

Table A-99 Results of multicollinearity test of simultaneous equation model No.18

Variables	R-squared	VIF
LNCHINAGDP	0.93521	**15.434**
LNWCAR	0.945036	**18.194**
LNUSCARSALES	0.650257	2.859
LNRAINFALL	0.485732	1.945
LNRICEP	0.801682	**5.042**
LNPALMOILP	0.651565	2.870

The simultaneous equation model No.18 has a multicollinearity problem in the variables lnChinaGDP, LNWCAR and lnRicep with VIFs 15.434, 18.194 and 5.042, respectively. However, lnUSCarsales, lnRainfall and lnPalmoilp have no multicollinearity problem with VIFs 2.859, 1.945 and 2.870, respectively.

Table A-100 Results of regression between lnChinaGDP with lnUSCarsales, lnWCAR, lnRainfall, lnRicep and lnPalmoilp

Dependent Variable: LNCHINAGDP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNWCAR	4.837491	0.369357	13.09708	0.0000
LNUSCARSALES	-0.80373	0.555446	-1.44701	0.1583
LNRAINFALL	0.013855	0.342038	0.040508	0.9680
LNRICEP	-0.29804	0.336679	-0.88525	0.3831
LNPALMOILP	0.167803	0.235862	0.711446	0.4823
C	-64.1742	7.734986	-8.29662	0.0000
R-squared	0.93521			
Adjusted R-squared	0.924411			

Table A-101 Results of regression between lnWCAR with lnUSCarsales, lnChinaGDP, lnRainfall, lnRicep and lnPalmoilp

Dependent Variable: LNWCAR Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNCHINAGDP	0.175947	0.013434	13.09708	0.0000
LNUSCARSALES	0.275949	0.097295	2.836215	0.0081
LNRAINFALL	0.058361	0.064357	0.906829	0.3717
LNRICEP	0.116065	0.061494	1.887439	0.0688
LNPALMOILP	-0.03336	0.044949	-0.7421	0.4638
C	10.88227	1.794895	6.0629	0.0000
R-squared	0.945036			
Adjusted R-squared	0.935875			

Table A-102 Results of regression between lnUSCarsales with lnChinaGDP, lnWCAR, lnRainfall, lnRicep and lnPalmoilp

Dependent Variable: LNUSCARSALES Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNWCAR	0.766236	0.270161	2.836215	0.0081
LNCHINAGDP	-0.08117	0.056097	-1.44701	0.1583
LNRAINFALL	-0.03913	0.108466	-0.36077	0.7208
LNRICEP	-0.41353	0.07776	-5.31805	0.0000
LNPALMOILP	0.072734	0.07441	0.977481	0.3361
C	5.835218	4.332633	1.346807	0.1881
R-squared	0.650257			
Adjusted R-squared	0.591966			

Table A-103 Results of regression between lnRainfall with lnUSCarsales, lnWCAR, lnChinaGDP, lnRicep and lnPalmoilp

Dependent Variable: LNRAINFALL Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNUSCARSALES	-0.11039	0.305988	-0.36077	0.7208
LNWCAR	0.457156	0.504126	0.906829	0.3717
LNCHINAGDP	0.003947	0.09745	0.040508	0.9680
LNRICEP	0.006188	0.182037	0.033995	0.9731
LNPALMOILP	0.155538	0.123737	1.257006	0.2185
C	0.218337	7.493738	0.029136	0.9769
R-squared	0.485732			
Adjusted R-squared	0.400021			

Table A-104 Results of regression between lnRicep with lnUSCarsales, lnWCAR, lnRainfall, lnChinaGDP and lnPalmoilp

Dependent Variable: LNRICEP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNRAINFALL	0.006225	0.183106	0.033995	0.9731
LNUSCARSALES	-1.17345	0.220653	-5.31805	0.0000
LNWCAR	0.914513	0.484526	1.887439	0.0688
LNCHINAGDP	-0.08541	0.096486	-0.88525	0.3831
LNPALMOILP	0.419866	0.101664	4.129938	0.0003
C	6.973943	7.407179	0.941511	0.3540
R-squared	0.801682			
Adjusted R-squared	0.768629			

Table A-105 Results of regression between lnPalmoilp with lnUSCarsales, lnWCAR, lnRainfall, lnRicep and lnChinaGDP

Dependent Variable: LNPALMOILP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNRICEP	0.863293	0.209033	4.129938	0.0003
LNRAINFALL	0.321682	0.255911	1.257006	0.2185
LNUSCARSALES	0.424365	0.434142	0.977481	0.3361
LNWCAR	-0.5404	0.72821	-0.7421	0.4638
LNCHINAGDP	0.098877	0.138981	0.711446	0.4823
C	0.72649	10.77624	0.067416	0.9467
R-squared	0.651565			
Adjusted R-squared	0.593492			

Table A-106 Results of multicollinearity test of simultaneous equation model No.19

Variables	R-squared	VIF
LNJAPANGDP	0.719	3.567
LNWCAR	0.836	**6.095**
LNUSCARSALES	0.628	2.687
LNRAINFALL	0.515	2.063
LNRICEP	0.80	**5.014**
LNPALMOILP	0.699	3.325

The simultaneous equation model No.19 has a multicollinearity problem in the variables LNWCAR and lnRicep with VIFs 6.095 and 5.014, respectively. However, lnJapanGDP, lnUSCarsales, lnRainfall and lnPalmoilp have no multicollinearity problem with VIFs 3.567, 2.687, 2.063 and 3.325, respectively.

Table A-107 Results of regression between lnJapanGDP with lnUSCarsales, lnWCAR, lnRainfall, lnRicep and lnPalmoilp

Dependent Variable: LNJAPANGDP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNWCAR	2.556339	0.417347	6.125211	0.0000
LNUSCARSALES	0.251636	0.627614	0.40094	0.6913
LNRAINFALL	-0.52181	0.386479	-1.35017	0.1871
LNRICEP	0.296859	0.380423	0.780339	0.4413
LNPALMOILP	-0.61603	0.266508	-2.31147	0.0279
C	-32.6834	8.739991	-3.73952	0.0008
R-squared	0.71968			
Adjusted R-squared	0.67296			

Table A-108 Results of regression between lnWCAR with lnUSCarsales, lnJapanGDP, lnRainfall, lnRicep and lnPalmoilp

Dependent Variable: LNWCAR Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNJAPANGDP	0.217372	0.035488	6.125211	0.0000
LNUSCARSALES	0.346869	0.17223	2.013991	0.0531
LNRAINFALL	0.294903	0.102829	2.867897	0.0075
LNRICEP	0.125386	0.109689	1.143098	0.2620
LNPALMOILP	0.122468	0.081334	1.505737	0.1426
C	5.883664	2.89296	2.033787	0.0509
R-squared	0.835939			
Adjusted R-squared	0.808595			

Table A-109 Results of regression between lnUSCarsales with lnJapanGDP, lnWCAR, lnRainfall, lnRicep and lnPalmoilp

Dependent Variable: LNUSCARSALES Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNWCAR	0.343363	0.170489	2.013991	0.0531
LNJAPANGDP	0.021181	0.052828	0.40094	0.6913
LNRAINFALL	-0.03178	0.115338	-0.27557	0.7848
LNRICEP	-0.42058	0.080825	-5.20364	0.0000
LNPALMOILP	0.07595	0.08277	0.917598	0.3661
C	12.44451	2.065108	6.026081	0.0000
R-squared	0.627841			
Adjusted R-squared	0.565815			

Table A-110 Results of regression between lnRainfall with lnUSCarsales, lnWCAR, lnJapanGDP, lnRicep and lnPalmoilp

Dependent Variable: LNRAINFALL Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNUSCARSALES	-0.07944	0.288276	-0.27557	0.7848
LNWCAR	0.729629	0.254413	2.867897	0.0075
LNJAPANGDP	-0.10978	0.081308	-1.35017	0.1871
LNRICEP	0.037314	0.17612	0.211867	0.8336
LNPALMOILP	0.079633	0.13188	0.603829	0.5505
C	-3.62096	4.808787	-0.75299	0.4573
R-squared	0.515165			
Adjusted R-squared	0.434359			

Table A-111 Results of regression between lnRicep with lnUSCarsales, lnWCAR, lnRainfall, lnJapanGDP and lnPalmoilp

Dependent Variable: LNRICEP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNRAINFALL	0.040039	0.188982	0.211867	0.8336
LNUSCARSALES	-1.12797	0.216765	-5.20364	0.0000
LNWCAR	0.332875	0.291205	1.143098	0.2620
LNJAPANGDP	0.067014	0.085879	0.780339	0.4413
LNPALMOILP	0.449131	0.110297	4.072006	0.0003
C	14.71666	4.250032	3.462717	0.0016
R-squared	0.80055			
Adjusted R-squared	0.767308			

Table A-112 Results of regression between lnPalmoilp with lnUSCarsales, lnWCAR, lnRainfall, lnRicep and lnJapanGDP

Dependent Variable: LNPALMOILP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNRICEP	0.792562	0.194637	4.072006	0.0003
LNRAINFALL	0.150788	0.249719	0.603829	0.5505
LNUSCARSALES	0.359447	0.391726	0.917598	0.3661
LNWCAR	0.57374	0.381036	1.505737	0.1426
LNJAPANGDP	-0.2454	0.106167	-2.31147	0.0279
C	-12.8705	6.252412	-2.05848	0.0483
R-squared	0.699249			
Adjusted R-squared	0.649123			

Table A-113 Results of multicollinearity test of simultaneous equation model No.20

Variables	R-squared	VIF
LNUSAGDP	0.851	**6.711**
LNWCAR	0.907	**10.756**
LNUSCARSALES	0.629	2.699
LNRAINFALL	0.504	2.018
LNRICEP	0.799	4.982
LNPALMOILP	0.668	3.016

The simultaneous equation model No.20 has a multicollinearity problem in the variables lnUSAGDP and lnWCAR with VIFs 6.711 and 10.756, respectively. However, lnUSCarsales, lnRainfall, lnRicep and lnPalmoilp have no multicollinearity problem with VIFs 2.699, 2.018, 4.982and 3.016, respectively.

Table A-114 Results of regression between lnUSAGDP with lnUSCarsales, lnWCAR, lnRainfall, lnRicep and lnPalmoilp

Dependent Variable: LNUSAGDP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNWCAR	2.374126	0.251454	9.44161	0.0000
LNUSCARSALES	-0.2046	0.378141	-0.54108	0.5924
LNRAINFALL	-0.24833	0.232856	-1.06646	0.2947
LNRICEP	-0.14769	0.229207	-0.64433	0.5243
LNPALMOILP	-0.23042	0.160572	-1.43501	0.1616
C	-23.7701	5.265886	-4.51397	0.0001
R-squared	0.850991			
Adjusted R-squared	0.826156			

Table A-115 Results of regression between lnWCAR with lnUSCarsales, lnUSAGDP, lnRainfall, lnRicep and lnPalmoilp

Dependent Variable: LNWCAR Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNUSAGDP	0.315149	0.033379	9.44161	0.0000
LNUSCARSALES	0.292047	0.127762	2.285863	0.0295
LNRAINFALL	0.181103	0.079857	2.267832	0.0307
LNRICEP	0.154166	0.079234	1.945709	0.0611
LNPALMOILP	0.066135	0.05926	1.116025	0.2733
C	6.799307	2.154056	3.156514	0.0036
R-squared	0.907027			
Adjusted R-squared	0.891532			

Table A-116 Results of regression between lnUSCarsales with lnUSAGDP, lnWCAR, lnRainfall, lnRicep and lnPalmoilp

Dependent Variable: LNUSCARSALES Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNWCAR	0.507919	0.2222	2.285863	0.0295
LNUSAGDP	-0.04724	0.087299	-0.54108	0.5924
LNRAINFALL	-0.05438	0.113551	-0.4789	0.6355
LNRICEP	-0.41946	0.080196	-5.23049	0.0000
LNPALMOILP	0.051744	0.079195	0.653376	0.5185
C	10.57824	2.649489	3.99256	0.0004
R-squared	0.629463			
Adjusted R-squared	0.567707			

Table A-117 Results of regression between lnRainfall with lnUSCarsales, lnWCAR, lnUSAGDP, lnRicep and lnPalmoilp

Dependent Variable: LNRAINFALL Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNUSCARSALES	-0.13952	0.291327	-0.4789	0.6355
LNWCAR	0.808086	0.356325	2.267832	0.0307
LNUSAGDP	-0.14709	0.137921	-1.06646	0.2947
LNRICEP	-0.01689	0.17759	-0.09513	0.9248
LNPALMOILP	0.116611	0.125963	0.925753	0.3620
C	-3.53	5.211944	-0.67729	0.5034
R-squared	0.504489			
Adjusted R-squared	0.421904			

Table A-118 Results of regression between lnRicep with lnUSCarsales, lnWCAR, lnRainfall, lnUSAGDP and lnPalmoilp

Dependent Variable: LNRICEP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNRAINFALL	-0.01785	0.187641	-0.09513	0.9248
LNUSCARSALES	-1.13709	0.217397	-5.23049	0.0000
LNWCAR	0.726829	0.373555	1.945709	0.0611
LNUSAGDP	-0.09243	0.143444	-0.64433	0.5243
LNPALMOILP	0.389149	0.110434	3.523818	0.0014
C	10.40924	5.052616	2.060169	0.0481
R-squared	0.799279			
Adjusted R-squared	0.765826			

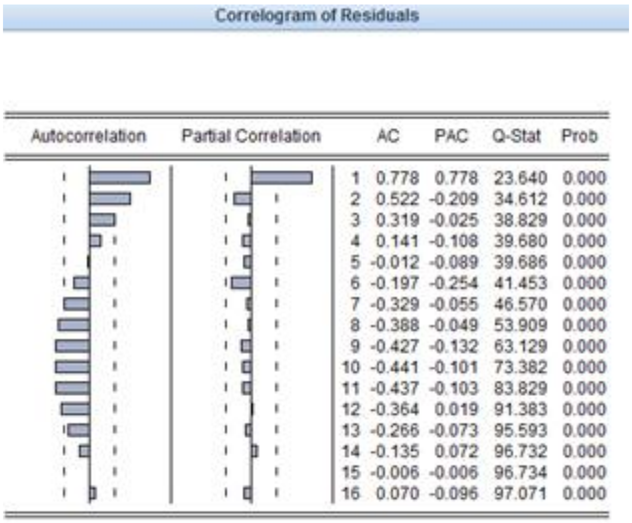
Table A-119 Results of regression between lnPalmoilp with lnUSCarsales, lnWCAR, lnRainfall, lnRicep and LNUSAGDP

Dependent Variable: LNPALMOILP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNRICEP	0.75226	0.213479	3.523818	0.0014
LNRAINFALL	0.238176	0.257279	0.925753	0.3620
LNUSCARSALES	0.271151	0.414999	0.653376	0.5185
LNWCAR	0.602736	0.540074	1.116025	0.2733
LNUSAGDP	-0.27876	0.194257	-1.43501	0.1616
C	-11.9728	7.180053	-1.66751	0.1058
R-squared	0.668444			
Adjusted R-squared	0.613185			

APPENDIX 4: Additional autocorrelation test

Autocorrelation (AC) and partial autocorrelations (PAC) along with Q-statistic and its associated p-value (Prob.) will be displayed. If there is no autocorrelation problem, Q-stat should be insignificant with large p-values (Prob. > 0.05).

Figure A-1 Correlogram[25] of Residuals on demand model



	AC	PAC	Q-Stat	Prob
1	0.778	0.778	23.640	0.000
2	0.522	-0.209	34.612	0.000
3	0.319	-0.025	38.829	0.000
4	0.141	-0.108	39.680	0.000
5	-0.012	-0.089	39.686	0.000
6	-0.197	-0.254	41.453	0.000
7	-0.329	-0.055	46.570	0.000
8	-0.388	-0.049	53.909	0.000
9	-0.427	-0.132	63.129	0.000
10	-0.441	-0.101	73.382	0.000
11	-0.437	-0.103	83.829	0.000
12	-0.364	0.019	91.383	0.000
13	-0.266	-0.073	95.593	0.000
14	-0.135	0.072	96.732	0.000
15	-0.006	-0.006	96.734	0.000
16	0.070	-0.096	97.071	0.000

Considering the Prob. in Figure A-1, it was found that Prob. < 0.05 we must reject the null hypothesis (H_o). It can be concluded that there is an autocorrelation problem.

[25] Correlogram also known as an autocorrelation plot, which is a plot of the sample autocorrelations.

Figure A-2 Correlogram of Residuals on demand model with AR(1) autocorrelation

Correlogram of Residuals

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	0.259	0.259	2.5500	
		2	-0.045	-0.120	2.6284	0.105
		3	0.210	0.276	4.4166	0.110
		4	0.085	-0.075	4.7151	0.194
		5	-0.083	-0.040	5.0117	0.286
		6	-0.088	-0.114	5.3581	0.374
		7	0.007	0.047	5.3604	0.498
		8	-0.045	-0.061	5.4595	0.604
		9	-0.092	-0.010	5.8836	0.660
		10	-0.089	-0.095	6.2970	0.710
		11	-0.208	-0.192	8.6306	0.567
		12	-0.196	-0.096	10.802	0.460
		13	-0.192	-0.160	12.962	0.372
		14	-0.142	-0.010	14.199	0.360
		15	0.003	0.063	14.200	0.435
		16	0.064	0.087	14.483	0.489

Considering the Prob. in Figure A-2, it found that Prob. > 0.05 we cannot reject the null hypothesis (H_o). It can be concluded that there is no autocorrelation problem.

Figure A-3 Correlogram of Residuals on supply model

Correlogram of Residuals

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.780	0.780	23.776	0.000
		2	0.522	-0.220	34.745	0.000
		3	0.290	-0.096	38.222	0.000
		4	0.074	-0.146	38.454	0.000
		5	-0.082	-0.040	38.754	0.000
		6	-0.231	-0.184	41.181	0.000
		7	-0.306	0.006	45.593	0.000
		8	-0.308	0.001	50.229	0.000
		9	-0.330	-0.179	55.750	0.000
		10	-0.375	-0.201	63.152	0.000
		11	-0.403	-0.109	72.058	0.000
		12	-0.379	-0.034	80.267	0.000
		13	-0.302	-0.018	85.692	0.000
		14	-0.171	0.082	87.511	0.000
		15	-0.019	0.047	87.535	0.000
		16	0.078	-0.144	87.951	0.000

Considering the Prob. in Figure A-3, it was found that Prob. < 0.05 we must reject the null hypothesis (H_o). It can be concluded that there is an autocorrelation problem.

Figure A-4 Correlogram of Residuals on supply model with AR(1) autocorrelation

Correlogram of Residuals

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	0.272	0.272	2.8197	
		2	-0.039	-0.122	2.8789	0.090
		3	0.156	0.220	3.8576	0.145
		4	0.133	0.017	4.6001	0.204
		5	-0.060	-0.082	4.7564	0.313
		6	-0.118	-0.096	5.3760	0.372
		7	-0.009	0.012	5.3793	0.496
		8	-0.133	-0.163	6.2302	0.513
		9	-0.147	-0.013	7.3083	0.504
		10	-0.092	-0.072	7.7449	0.560
		11	-0.269	-0.256	11.663	0.308
		12	-0.200	-0.031	13.913	0.238
		13	-0.122	-0.122	14.787	0.253
		14	-0.108	-0.046	15.508	0.277
		15	-0.028	0.057	15.557	0.341
		16	0.092	0.078	16.135	0.373

Considering the Prob. in Figure A-4, it was found that Prob. > 0.05 we cannot reject the null hypothesis (H_o). It can be concluded that there is no autocorrelation problem.

APPENDIX 5: Backgrounds

Natural Rubber Production

Natural rubber (NR) is produced by the tapping process of Hevea Brasiliensis, or Para rubber. These plants generally have economic life for 32 years but they may live up to 100 years or even more. The plantation begins yielding from 6th year afterward. Generally, once in every two days rubber trees are tapped (each time yielding about 50 grams of latex). When the bark of the tree is tapped, thin slivers of bark are expurgated; the latex exudes from the slit and drips into a cup ("Rubber seasonal report," 2010).

The rubber tree flourishes in the tropical climate with annual precipitation of 2,000-4,000 mm evenly distributed throughout the year, and temperatures ranging between 24 and 28 Celsius degree. Therefore, in only a few tropical countries, the production of natural rubber is concentrated. However, as a result of improved breeding programs, rubber tree areas can be found in locations with a light rain as 1,500 mm per year and an arid season of up to 5 months (Brentin and Sarnacke, 2011).

The leaves of the tree die and fall off and new leaves are formed during the mid-February (lasting for 4 to 6 weeks), so the metabolism of the tree and the latex production are importantly affected. Because the extreme weather and aging trees in the key rubber growing area also causes the rubber production fluctuate between months, it is normally low during the rainy season. These seasonal changes are important determinants influencing the market ("Rubber seasonal report," 2010).

The collection of natural rubber from the tapping process converts it into a storable and marketable form such as concentrated latex, ribbed smoked sheet rubber (RSS), block rubber and crepe Rubber.

Thailand produces rubber in different forms such as blocked rubber (Standard Thai Rubber: STR), rubber ribbed smoked sheet (RSS), concentrated latex and rubber compound (Rubber Research Institute of Thailand, 2012). The rubber processed products can be preserved for longer.

Ribbed smoked sheet rubber (RSS)

Ribbed smoked sheet rubber is processed by smoking the un-smoked rubber sheets in the smoke chambers with temperature controlled at below 65°C. After that, grading the smoked rubber sheets into grade number one to number five (RSS1, RSS2, RSS3, RSS4, RSS5) according to international natural rubber type and grade description ("Rubber smoked sheet," n.d.).

Block rubber (Standard Thai Rubber: STR)

STR is available in five grades i.e. STR-5L, STR5, STR10, STR20 and STR20CV. Only STR5L and STR20 are volume traded in the rubber industry. STR-20 is a type of block rubber that has the most exported of Thailand. It processed from field coagulum (cup-lump) and mixed with rubber sheet or processed from cup-lump only. The processes start by converting rubber into crumbs and drying the rubber through a pelletizer machine. ("Standard Thai Rubber," n.d.).

Concentrated Latex

Concentrated latex is fresh field latex that is preserved with added chemicals and centrifuged to obtain concentrated latex of 60 percent DRC. Ammonia is added during the process to enhance the preservation of latex ("Latex," n.d.).

APPENDIX 6: Results of Cook’s Distance

Cook’s Distance is a measure of the "influence" of each observation: how much the predicted scores for other observations would differ if one observation were omitted. Cook’s Distance over 1 is influential.

Table A-120 Results of Cook’s Distance

Dependent Variable: lnRubberq			
Independent Variables	Cook's Distance		
	Minimum	Maximum	Mean
lnRainfall	0.00005	0.13232	0.02639
lnRicep	0.00001	0.15178	0.02937
lnUSAGDP	0.00000	0.16637	0.03131
lnUSCarsales	0.00002	0.40392	0.03497

Calculated by SPSS 13.0 software

The results of Cook’s Distance show that the maximum value still < 1, it can conclude that no influential variables.

APPENDIX 7: The R-squared values from the ordinary least squares regression between exogenous variables

Table A-121 Results of regression between lnUSAGDP with lnUSCarsales, lnRicep and lnRainfall

Dependent Variable: LNUSAGDP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNUSCARSALES	1.855311	0.583955	3.177147	0.0033
LNRAINFALL	0.632937	0.397569	1.592019	0.1212
LNRICEP	0.627352	0.300385	2.08849	0.0448
C	-28.6751	10.0621	-2.84981	0.0076
R-squared	**0.391813**			
Adjusted R-squared	0.334796			

Table A-122 Results of regression between lnUSCarsales with lnUSAGDP, lnRicep and lnRainfall

Dependent Variable: LNUSCARSALES Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNUSAGDP	0.129251	0.040682	3.177147	0.0033
LNRAINFALL	0.084339	0.107987	0.781005	0.4405
LNRICEP	-0.32767	0.061543	-5.32422	0.0000
C	16.42017	0.646344	25.40471	0.0000
R-squared	**0.543628**			
Adjusted R-squared	0.500843			

Table A-123 Results of regression between lnRainfall with lnUSAGDP, lnUSCarsales and lnRicep

Dependent Variable: LNRAINFALL Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNUSCARSALES	0.221784	0.283973	0.781005	0.4405
LNUSAGDP	0.115953	0.072834	1.592019	0.1212
LNRICEP	0.324918	0.124436	2.611123	0.0136
C	0.719223	4.820721	0.149194	0.8823
R-squared	**0.374463**			
Adjusted R-squared	0.315819			

Table A-124 Results of regression between lnRicep with lnUSAGDP, lnUSCarsales and lnRainfall

Dependent Variable: LNRICEP Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNRAINFALL	0.540566	0.207024	2.611123	0.0136
LNUSCARSALES	-1.43356	0.269253	-5.32422	0.0000
LNUSAGDP	0.191209	0.091554	2.08849	0.0448
C	23.38667	4.647411	5.032193	0.0000
R-squared	**0.601014**			
Adjusted R-squared	0.563609			

APPENDIX 8: Instrumental Variables Estimator

Instrumental Variable should be:

1. Correlated with endogenous explanatory variable; Cov(Z, lnRubberp) ≠ 0

2. Uncorrelated with error term; Cov(Z, e) = 0

Table A-125 Covariance between endogenous explanatory variable and exogenous variable

	LNRAINFALL	LNRICEP	LNUSAGDP	LNUSCARSELL
LNRUBBERP	0.090656	0.136569	0.177158	-0.014

The results from table A-125 show that the covariance between lnRubberp with lnRainfall, lnRicep, lnUSCarsales and lnUSAGDP are not zero, which mean they are correlated with endogenous explanatory variable (lnRubberp).

Table A-126 Covariance between error term and exogenous variable

	LNRAINFALL	LNRICEP
ERROR1	0.0000000000000455 ≈ 0	-0.0000000000000223 ≈ 0
	LNUSAGDP	LNUSCARSELL
ERROR2	0.0000000000000150 ≈ 0	-0.0000000000000099 ≈ 0

Where error1 is error term of supply equation and error2 is error term of demand equation. The results from table A-126 show that the covariance between error term with lnRainfall, lnRicep, lnUSCarsales and lnUSAGDP are zero, which mean they are uncorrelated with error term.

Thus, we can conclude that lnRainfall, lnRicep and lnUSAGDP are valid instrumental variables that will not yield bias in estimation (Wooldridge, 2012).

APPENDIX 9: Endogeneity Test for endogenous explanatory variable Rubberp

Table A-127 Results of endogeneity test for explanatory variable in demand model

Dependent Variable: LNRUBBERQ Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNRUBBERP^{NS}	-0.0404	0.065849	-0.61347	0.5440
LNUSAGDP****	1.38501	0.073716	18.78838	0.0000
LNUSCARSALES^{NS}	0.271734	0.17769	1.529263	0.1363
RESID01^{NS}	-0.0337	0.11916	-0.28277	0.7792
C^{NS}	-4.08249	2.767262	-1.47528	0.1502
*** Significant at 0.01 level ** Significant at 0.05 level * Significant at 0.10 level NS No Significant				

By adding RESID01 as additional explanatory variable in the demand model, table A-127 presents the endogeneity test result. The coefficient of RESID01 has p-value of 0.7792, so we fail to reject the null hypothesis that the true parameter is equal to zero at the 0.10 level of significance. Thus, the coefficient of RESID01 is no significant values. It can be concluded that this demand model has no endogeneity problem.

Table A-128 Results of endogeneity test for explanatory variable in supply model

Dependent Variable: LNRUBBERQ Method: Least Squares Included observations: 36				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNRUBBERP***	3.353918	0.115401	29.06306	0.0000
LNRAINFALL***	-3.76497	0.213031	-17.6733	0.0000
LNRICEP***	-2.63694	0.115375	-22.8554	0.0000
RESID01***	-3.42801	0.153593	-22.3188	0.0000
C***	34.33118	1.28389	26.73997	0.0000
*** Significant at 0.01 level ** Significant at 0.05 level * Significant at 0.10 level NS No Significant				

By adding RESID01 as additional explanatory variable in the supply model, table A-128 presents the endogeneity test result. The coefficient of RESID01 has p-value of 0.00, so we reject the null hypothesis that the true parameter is equal to zero at the 0.01 level of significance. Thus, the coefficient of RESID01 is significant at 1 percent level. It can be concluded that this supply model has endogeneity problem.